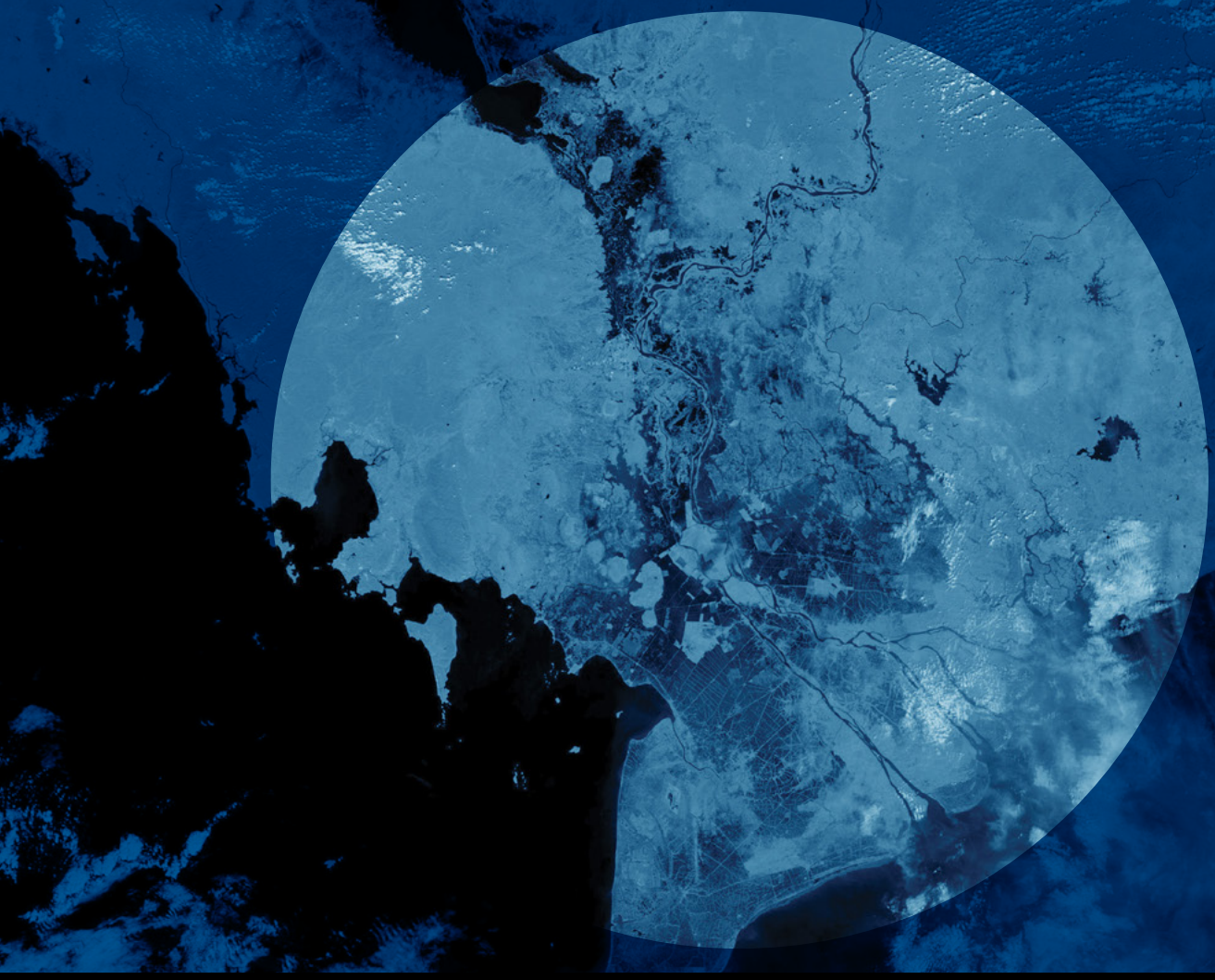
The Economist Intelligence Unit

Water security threats demand new collaborations

Lessons from the Mekong River Basin



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Preface

Water security threats demand new collaborations: Lessons from the Mekong River Basin is an Economist Intelligence Unit (EIU) report, commissioned by DuPont as part of the Global Food Security Index (GFSI) research programme. This report discusses the key findings from the research on water security challenges and solutions in the Mekong River Basin.

Robert Smith, research analyst, was the project manager. Katherine Stewart, consulting analyst, provided research, analytical and editorial support. Hilary Steiner, North American director of public policy, and Sumana Rajarethnam, principal of public policy, served as senior advisers. Peter Ouvry provided editorial support and Mike Kenny was responsible for layout and design.

Acknowledgements

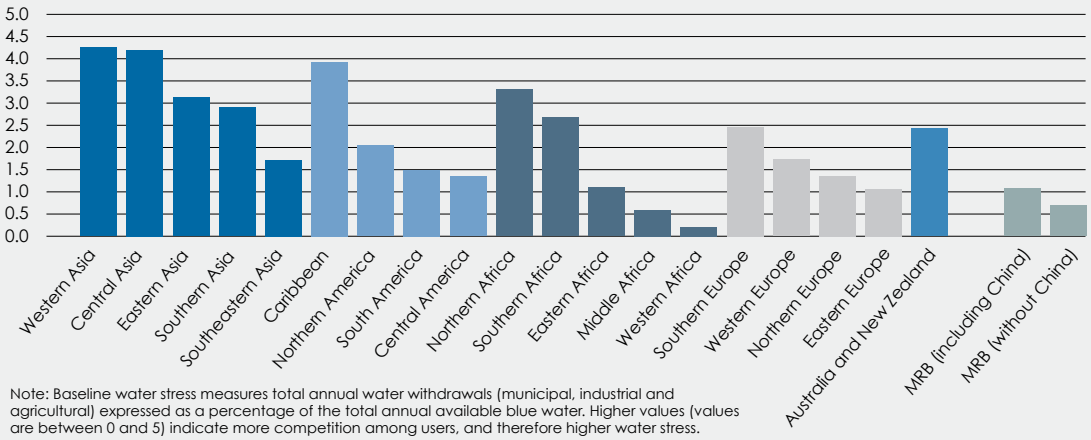
We would like to thank Jon Keesecker for lending research and analytical support to this project. We would also like to extend thanks to the experts interviewed for this report, including Dr Richard Cronin (The Stimson Center), Maureen Harris (International Rivers), Robyn Johnston (International Water Management Institute), Dr Peter King (Institute for Global Environmental Studies) and Dr Bjoern Ole Sander (International Rice Research Institute).

Executive summary

Water security is often understood as the capacity of a population to safeguard access to water resources in sufficient quantity and quality to sustain livelihoods and socioeconomic development.[1] In practice, the concept embraces issues of health and sanitation, food security, natural disasters, and economic development. It is difficult to overstate the importance of water. Agriculture accounts for 70% of water withdrawals worldwide, and 1.5bn people work in water-related sectors (agriculture, energy and environmental protection, among others).[2] Yet a large part of the world's population lacks adequate access to water resources. Globally, more than 600m people do not have access to clean drinking water and a staggering 2.4bn lack adequate sanitation. And the challenge of water provision will only continue to grow: in 2025, 1.8bn people will live in countries with absolute water scarcity, and by 2050 water withdrawals for agriculture

Regional water stress (baseline)

0–5 (see note)



Note: Baseline water stress measures total annual water withdrawals (municipal, industrial and agricultural) expressed as a percentage of the total annual available blue water. Higher values (values are between 0 and 5) indicate more competition among users, and therefore higher water stress. Scores reflect average of countries by region as designated by the United Nations Statistics Division.

Sources: Gassert, F., P. Reig, T. Luo, and A. Maddocks. 2013. "Aqueduct country and river basin rankings: a weighted aggregation of spatially distinct hydrological indicators." Working paper. Washington, DC: World Resources Institute, December 2013. Available online at: http://wri.org/publication/aqueduct-country-river-basin-rankings.

1 The UN Educational, Scientific and Cultural Organisation (UNESCO). (2012). *International Hydrological Programme, Strategic Plan of the Eighth Phase*.

2 UNESCO. (2016). *United Nations World Water Day Development Report 2016: Water and Jobs*.

will need to increase by 15% to sustain agricultural production.[3] So great is the threat posed to development by water insecurity that the UN has incorporated sustainable water and sanitation into its Sustainable Development Goals.

Perhaps more than any other region in the world, the Mekong River Basin (MRB) provides a case study of the importance of striking a balance between water, food and energy consumption. The Mekong basin is fed by a unique bounty of fresh water capable of supporting energy and food production that has become integral to the regional and global economies. Yet the long-term sustainability of the region's precious water resources is increasingly threatened by energy and agricultural production, vulnerability to climate change, and a lack of co-ordination among governments. Charting a clearer course towards water security will require increased collaboration between public, private and non-profit actors at the national and regional levels, as well as innovative approaches to addressing challenges in water-resource management.

This policy brief surveys the myriad threats to water security in the MRB as well as the role of collaboration and innovation in addressing them. Although the Mekong basin enjoys greater water abundance than many other parts of the world and has the resources to be water-secure, the region's challenges—especially those around the water, food and energy nexus—and the potential solutions to them make it an informative case study for water security in general in regions around the globe. Key findings include:

- **Water abundance is not a substitute for good water governance**. While the Mekong basin is water abundant, the long-term sustainability of water resources in the region is challenged by the competing interests of energy and agriculture. This conflict requires countries in the region to approach water resources management more collaboratively—engaging with neighbouring governments and involving the private sector, non-governmental organisations and local communities in decisions around water usage.

- **The ever-growing threats of climate change, economic development and rapid population growth demand comprehensive solutions that address both increased demand for and finite availability of food, energy and water resources**. Extensive hydropower development and climate change-related natural disasters represent some of the greatest threats to water security in the Mekong basin. New hydropower dams could prevent the migration of 70% of fish in the Mekong mainstream, negatively impacting the basin's US$17bn per year fisheries industry.

- **Successful water security solutions will minimise the trade-offs in the fragile food-energy-water nexus**. Developing mechanisms to adapt to climate change, improving water and sanitation infrastructure, and providing agricultural innovations that reduce water use, together with other interventions, are among the most effective solutions to addressing water resource challenges. Techniques such as alternate wetting and drying (AWD) can reduce water use by 30%, while better financial services and more resilient crop varieties may reduce farmers' financial and production risks related to natural disasters.

- **Water resource management is a fundamental component of food security**. Only through proper water resource management will countries be able to continue to address food insecurity

3 The UN defines absolute water scarcity as conditions under which there is less than 500 cu metres of water per person per year.

challenges. Food insecurity remains a key concern for the countries of the Mekong basin, particularly in areas that face water stress from drought, flooding and natural disasters. In Cambodia and Laos, 25% of the population still lack adequate potable water, and poor water infrastructure continues to contribute to food insecurity.

- **Regional organisations can support water security by providing a platform for discussion, but they require stronger enforcement mechanisms to influence national-level water policy**. The Mekong River Commission (MRC) remains a unique and important body for regional water governance. It has played a critical role in reassessing the social and economic value of the basin's resources, and, with continued funding, it has the potential to remain the most effective avenue for basin-wide water-resource management. However, while the MRC facilitates conversation among member countries around water usage and security, it lacks the teeth to mediate disagreements around the development of major projects (eg, hydropower) along the basin.

- **Improved, effective water management at the national level requires increased agency co-ordination and implementation of regulations**. Overlapping mandates and poor co-ordination between agencies on water policy currently limits the ability of governments to regulate the impact of new development on water resources. Properly designed Environmental Impact Assessment (EIA) procedures can support efforts to mitigate and remediate environmental damage caused by new development, although current EIA procedures in the Mekong basin are weak.

- **Amid challenges to transboundary water-resource management, donor, multilateral and international support for local and national interventions is critical to improving water security around the globe**. This type of support, as well as other collaborations across public, private and non-profit actors, is becoming increasingly important to creating solutions for water security, particularly as relevant government entities become less willing to follow supranational governance frameworks. In the Mekong basin, donors and multilateral institutions have pledged billions of dollars in aid and loans to improve infrastructure for economic development and climate adaptation. These types of investments could include more emphasis on water security going forward.

- **The private sector can play an important role in reducing water insecurity around the globe, but this requires more innovative action**. Private-sector actors offer valuable philanthropic support for water sustainability programmes. However, they also have an important role to play in developing socially and environmentally responsible products and value chains. For example, the consumer goods company Unilever partnered with the Vietnamese government to market and distribute a less water-intensive fabric softener to local populations in order to reduce water use.

The Mekong basin: A river runs through it

The Mekong River Basin (MRB) is a region of vast and potentially lucrative water resources. It cradles the Mekong river for almost 5,000 km and is home to more than 70m people across six countries.[4] The basin's rich biodiversity includes 20,000 plant and 2,500 animal

4 Cambodia, China, Laos, Myanmar, Thailand and Vietnam.

species, making it a natural endowment matched only by the Amazon and Congo river basins.[5] Despite the long-standing economic challenges faced by these countries, the MRB is an intensely productive region. Its agriculture and fisheries not only support its own population, but also contribute to supporting that of the world. The Lower Mekong Basin produces 15% of the world's rice and one-quarter of its freshwater fish. The fisheries alone have an estimated annual value of US$17bn.[6] In recent decades, the Mekong river's massive, untapped hydropower potential has also drawn increased attention and attracted dozens of new dam proposals, amounting to hundreds of gigawatts of installed hydroelectric capacity, that some in the basin view as a pathway to future economic growth.

Despite the MRB's natural wealth, governments within the basin face a number of resource-related challenges that threaten the prosperity of the region. Some of these—such as climate change—have been foisted on them, while others are the result of unilateral decisions by particular countries about how best to pursue their individual economic interests. For instance, new hydropower construction threatens to impact agriculture and fisheries in the basin's downstream countries. Agricultural run-off in the form of pesticides and fertiliser also represents a threat to water quality in some areas, and in coming decades urbanisation and new development could lead to greater industrial pollution. At the same time, vulnerability to natural disasters and food insecurity is already high in some areas, and climate change is a major threat as changes in temperature and rainfall exacerbate drought and flooding. By 2100 rising sea levels could inundate one-quarter of the Mekong delta, displacing millions of people and jeopardising agriculture productivity in Vietnam. Even amid the wealth of water resources in the Mekong basin, the failure to address these problems in a collaborative way that takes into account the transboundary impacts of water use could result in heavy costs for countries in the region.

The relatively new and incomplete policy frameworks for ensuring integrated water-resources management and transboundary collaboration—at both regional and national levels—remain insufficient to confront these challenges. Given the wide range of issues related to water security in the Mekong basin, as well as the diversity of challenges faced both within and among its countries, crafting policy solutions is a daunting task. Water governance is more developed today than it was 20 years ago, but so too have the challenges grown. At the national level, new water policies remain poorly implemented and environmental impact assessment procedures have failed to curtail the worst effects of development. At the regional level, the 1995 Mekong Agreement—once hailed as groundbreaking—has been shown to lack teeth. As economic development and climate change continue, the costs of prevention and disaster remediation have mounted. In the coming decades, these impacts could prove disastrous for the environment in the MRB as well as for the economies of its countries. Whether the rising threats to water security have outpaced improvements in water-resource management is up for debate, but there is little question that major policy gaps remain and that addressing these will require governments in the region to renew their efforts to achieve effective water governance. ■

5 Fasman, J. (2016). *The Economist*. "The Mekong: Requiem for a River". Available at: http://www.economist.com/news/essays/21689225-can-one-world-s-great-waterways-survive-its-development

6 Mekong River Commission (MRC). (2016). *Catch and Culture*. Volume 21, No. 3.

Growing threats to water security in the Mekong River Basin

The threats to water security in the MRB are not entirely different from those affecting other parts of the world, though the region's diverse climate and relative abundance of water present it with a uniquely broad set of concerns. Unlike in water-stressed regions of the world, many areas in the Mekong basin will face both seasonal drought and flooding. Additionally, as countries such as China, Laos and Cambodia hang their hopes for economic development on hydropower or industrialisation, they and their neighbours will ultimately have to confront the impact that these choices will have on other industries, including agriculture and fisheries. Despite the uniqueness of the MRB, understanding the challenges facing the region could help to illustrate how collaboration and innovation on energy-, water- and food-related issues could improve the wellbeing of communities around the globe.

The floodgates open on hydropower

Hydropower is viewed by countries in the Mekong basin—and particularly by China, Laos and Cambodia—as a pathway to economic growth and energy security. In China, hydropower has been touted as a green alternative to coal and a means to develop the country's western reaches. In the Lower Mekong Basin, Laos and Cambodia regard hydropower as important both for domestic energy consumption and as an important commodity for export to their wealthier neighbours.[7] Laos has indicated that it hopes that hydropower exports will be its main source of revenue by 2025.[8] According to the Mekong River Commission (MRC), the nine mainstream dams that Laos hopes to build could result in US$4.6bn in annual revenue for that country's government by 2030.[9] The first of the projects that will be

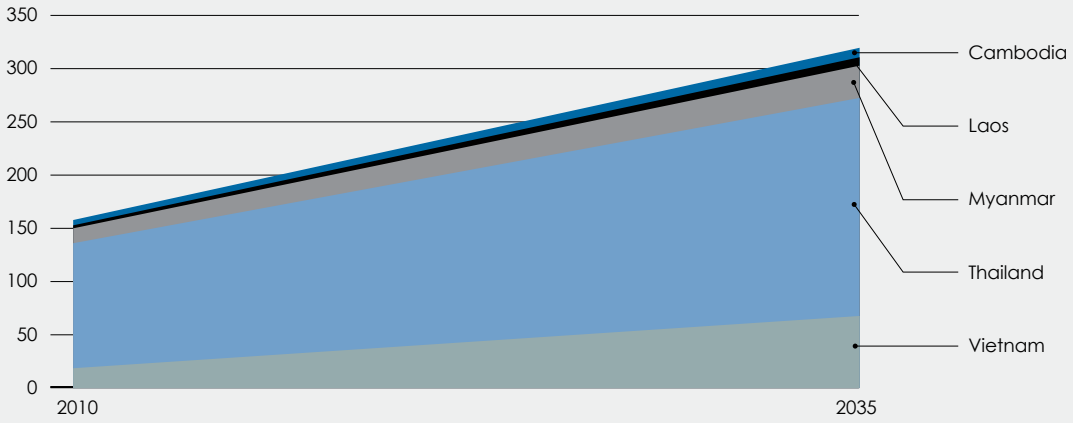
7 The lower 86% of the MRB's area, which falls within Myanmar, Laos, Thailand, Cambodia and Vietnam, is known as the Lower Mekong Basin; the northern portion of the river basin lying within China is known as the Upper Mekong Basin, or the Lancang River Basin (in reference to the river's Chinese name).

8 Fasman, J. (2016). *The Economist*. "The Mekong: Requiem for a River". Available at: http://www.economist.com/news/essays/21689225-can-one-world-s-great-waterways-survive-its-development

9 Cronin, R.; Weatherby, C. (2015). The Stimson Center. *Letters from the Mekong: Time for a New Narrative on Mekong Hydropower*.

Energy demand in the Mekong River Basin, 2010-35

Million tons of oil equivalent (Mtoe)



Source: Asian Development Bank.

completed—the Xayaburi dam—will reserve 95% of its power output for export to Thailand, and the bulk of total hydropower production in Laos is to be exported. Energy demand in the Mekong region is expected to double between 2010 and 2025, driven in large part by rising demand in Thailand and Vietnam.[10] However, Laos also views hydropower as necessary for the development of local mineral deposits.[11] In Cambodia, too, hydropower ambitions are driven in part by the need to provide more, and cheaper, energy for domestic consumption and to satisfy the needs of nascent light industries such as garment manufacturing.

At present the MRB's vast hydropower potential remains largely untapped, particularly in the Lower Mekong Basin. Yet the economic potential of the river is resulting in rapid change: total installed hydropower capacity along the Mekong is estimated at around 60 GW, split roughly between the upper and lower Mekong river.[12] [13] Until 1995, there were no dams on the Mekong mainstream; however, in the past 20 years, China has constructed six dams on the upper Mekong river with a combined total of 15.4 GW of installed capacity, and it is planning 14 additional dams that will provide 16 GW of installed capacity.[14] [15] In the Lower Mekong Basin, where only tributaries of the Mekong river have previously been dammed, 11 new mainstream dams are planned for construction.[16] [17] In late 2012 Laos broke ground on the Xayaburi dam, and it has since proceeded with plans for two more dams, both downstream at Don Sahong and upstream at Pak Beng.

However, new hydropower development poses serious risks for downstream water users in the Mekong basin. Grounds for objecting to such projects have ranged from the expected displacement of communities to the prevented migration of myriad fish species, many of which support the food security and livelihoods of communities in the basin. "Dams on the Mekong mainstream pose a major threat to the river's rich fisheries which sustain

10 Asian Development Bank, *Energy Outlook for Asia and the Pacific. 2013*.

11 Cronin, R.; Hamlin, T. (2012). The Stimson Center. *Mekong Turning Point: Shared River for a Shared Future*.

12 MRC. (2010). *State of the Basin Report*.

13 Dore, J.; Xiaogang, Y.; Yuk-shing, K. (2007). "China's energy reforms and hydropower expansion in Yunnan", in Lebel, L.; Dore, J.; Daniel, R.; Koma, Y.S. *Democratizing Water Governance in the Mekong Region*. Chiang Mai: Silkworm Books. pp. 55–92.

14 Chellaney, B. (2013). *Water: Asia's New Battleground*. Georgetown University Press.

15 Fasman, J. (2016). *The Economist*. "The Mekong: Requiem for a River". Available at: http://www.economist.com/news/essays/21689225-can-one-world-s-great-waterways-survive-its-development

16 Ibid.

17 This includes eight dams in Laos and three in Cambodia.

"Dams on the Mekong mainstream pose a major threat to the river's rich fisheries which sustain the food security and livelihoods of millions of people in the Mekong Basin."

Maureen Harris, International Rivers

the food security and livelihoods of millions of people in the Mekong Basin," according to Maureen Harris, Southeast Asia Programme Director for International Rivers, an environmental non-governmental organisation (NGO). "Thousands of local riverine communities are directly reliant on the river and its fisheries as a vital source of protein, as well as economic and cultural well-being and identity." According to International Rivers, 70% of the Mekong's commercial fish migrate long distances and could be blocked by the dams, dramatically reducing the future economic value of the MRB's fisheries.[18] The Vietnam government estimates that hydropower development could reduce capture fisheries yield by 50% in Cambodia and Vietnam.[19] The dams could also cut sediment deposits in half by blocking virtually all of the sediment arriving from the Upper Mekong Basin.[20] Reductions in sediment, which is critical for nutrient-loading, could reduce total rice production in Vietnam by 6.7% by 2050, with 2% additional losses in every decade thereafter.[21] While the MRC has estimated a net economic benefit of US$33bn over a 20-year period for 11 new Lower Mekong Basin dams, others have estimated US$274bn in economic losses based on the same data, accruing largely to Laos' downstream neighbours.[22]

A region of extreme vulnerability to climate change

While there is considerable uncertainty about the long-term impacts of climate change on temperatures and rainfall, the Mekong basin is generally forecast to experience greater seasonal extremes than at present. Several estimates foresee overall increases in temperatures and precipitation. The International Centre for Environmental Management estimates increases in the average daily maximum temperature by 2050 in the range of 1.6-4.1 degrees Celsius.[23] Annual precipitation, meanwhile, could rise by 3-14%, increasing river flow volumes, particularly in the downstream reaches of the Lower Mekong Basin. Even in the absence of such increases, however, experts forecast drier dry seasons and wetter wet seasons. Furthermore, the region could be dramatically affected by sea level increases of 65-100 cm by the end of the century.[24]

These changes are likely to lead to a variety of water-related threats—including increased drought, flooding and saltwater intrusion—with particularly dire consequences for agricultural production in the Mekong basin. Changes in rainfall could translate into a 10-100% increase in annual drought-months across the region. Decreases in dry-season rainfall would hurt rice production and place particular stress on vulnerable areas such as north-eastern Thailand and the Tonlé Sap basin in Cambodia.[25] A USAID study found that the most severely affected areas of the basin could see yields fall by 3-12% for export commodities and staple foods like rain-fed rice and maize.[26] Meanwhile, in the Mekong delta saltwater intrusion could reduce the area of land available for agriculture. By 2100, sea level increases could expose 70% of the delta's agricultural land to saline and could force 5m inhabitants to leave their homes.[27]

18 International Rivers. (2009). *Mekong Mainstream Dams: Threatening Southeast Asia's Food Security*.

19 Vietnam Ministry of Natural Resources and Environment. (2015). *Draft Study on the Impacts of Mainstream Hydropower on the Mekong River: Draft Impact Assessment Report*.

20 International Rivers. (2014). *World Rivers Review*. Vol. 29, No. 4.

21 Vietnam Ministry of Natural Resources and Environment. (2015). *Draft Study on the Impacts of Mainstream Hydropower on the Mekong River: Draft Impact Assessment Report*.

22 Cronin, R.; Weatherby, C. (2014). The Stimson Center. *Letters from the Mekong: Obstacles to Equitable Hydropower Development in the Lower Mekong Basin*.

23 USAID. (2013). *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Main Report*.

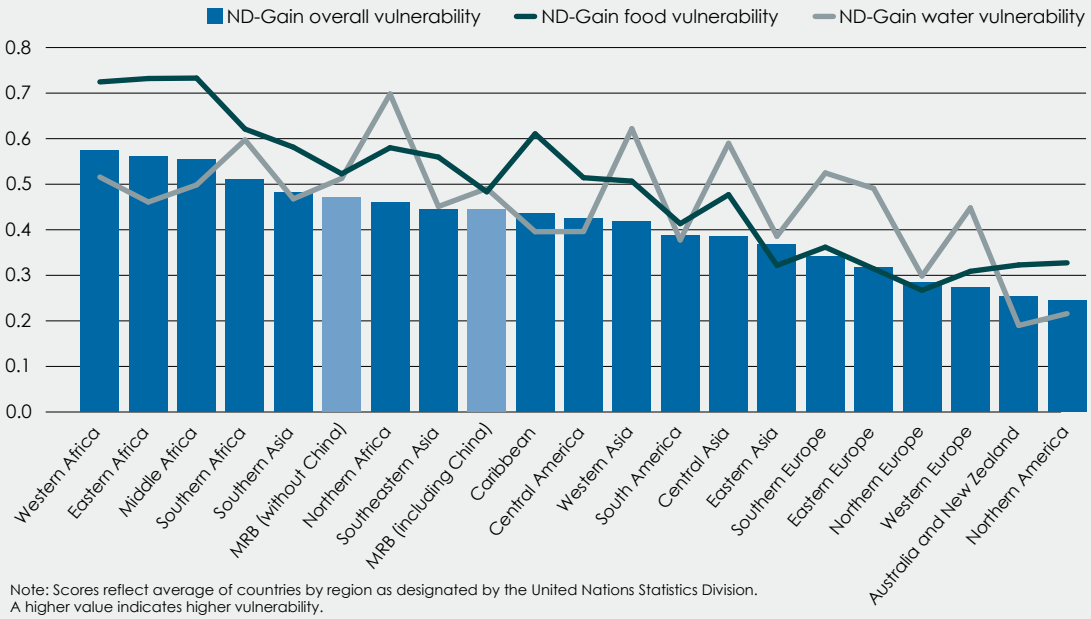
24 International Centre for Environmental Management. (2009). *Forum Report Volume I: Mekong Delta Climate Change Forum*.

25 MRC. (2011). *Agriculture and Irrigation Programme: 2011-2015 Programme Document*.

26 USAID. (2013). *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Main Report*.

27 International Centre for Environmental Management. (2009). *Forum Report Volume I: Mekong Delta Climate Change Forum*.

Regional climate change-related food and water vulnerability



Note: Scores reflect average of countries by region as designated by the United Nations Statistics Division. A higher value indicates higher vulnerability.

Source: ND-Gain Country Index.

The economic impact of water-related natural disasters has the potential to be extremely severe for communities in the Mekong basin, where some 60% of the population rely on agriculture for at least part of their livelihoods and where built infrastructure is often insufficient to cope with extreme weather events.[28] This has been illustrated most recently in Thailand and Vietnam, two of the most disaster-prone countries in the region, where flooding and drought have caused enormous economic losses. The majority of Thailand's 77 provinces were declared disaster zones due to massive floods in 2011, and even parts of the capital, Bangkok, were submerged. The floods took 815 lives and, according to the World Bank, caused in excess of US$45bn in economic damages and losses.[29] In the Mekong delta, which accounts for 50% of Vietnam's rice production and 33% of its GDP, drought can have a disastrous impact on the economy. Over the past two years the delta has been struck by its worst drought in 90 years, reducing incomes for 1.75m people. Between late 2014 and late 2016 economic losses from drought and saltwater intrusion were estimated at US$674m.[30]

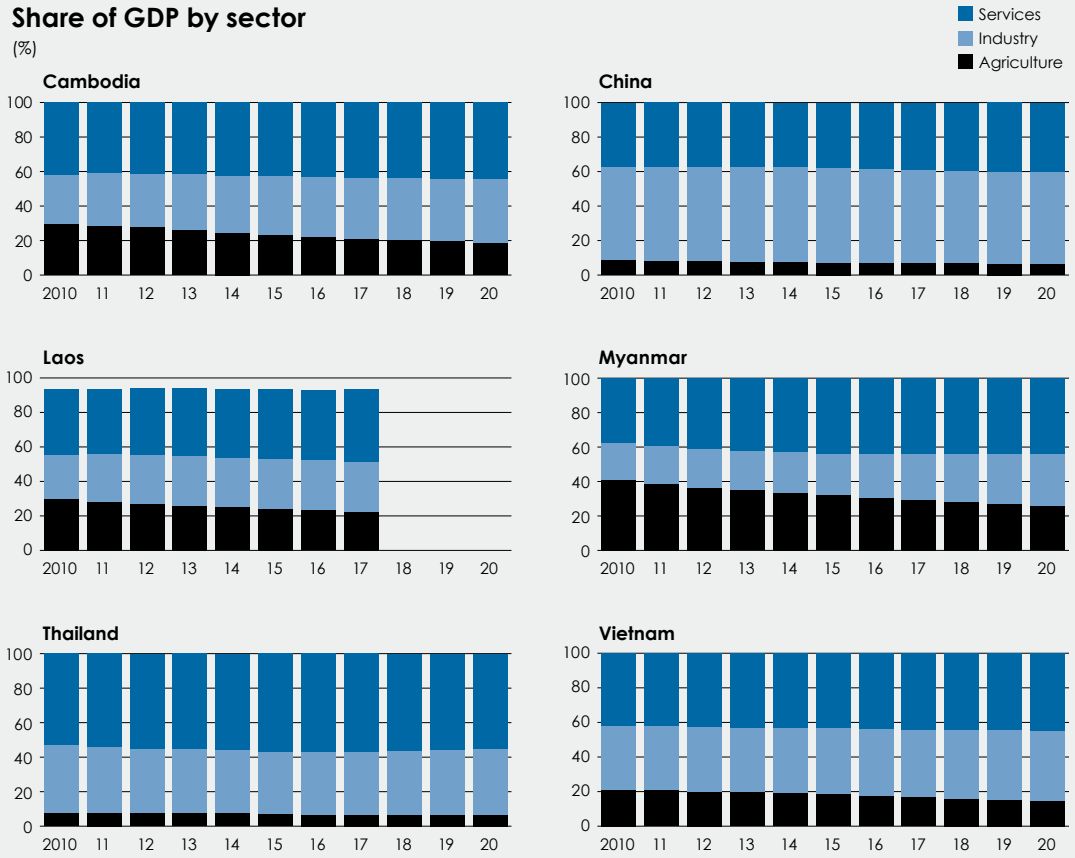
Other challenges from agricultural and industrial activity

Increased agricultural activity and industrial development present important but smaller-scale challenges to water security in the MRB. "Total annual flow in the Mekong averages around 475 cu km," according to Robyn Johnston, principle researcher for the International Water Management Institute (IWMI) and a former contributor to the MRC's Basin Development Plan. "This is a huge amount of water, so it is actually difficult to have an impact on the volume security at the basin scale, although local shortages can

28 MRC. (2011). *Agriculture and Irrigation Programme: 2011-2015 Programme Document.*

29 World Bank. (2011) The World Bank Supports Thailand's Post-Floods Recovery Efforts. Accessible at: http://www.worldbank.org/en/news/feature/2011/12/13/world-bank-supports-thailands-post-floods-recovery-effort

30 UN Disaster Risk Management Team. (2016). *Vietnam is Recovering from its Strongest Ever Drought and Saltwater Intrusion.*



Note: 2018-20 forecasts unavailable for Laos.
Source: The Economist Intelligence Unit.

occur." Overall, the MRC estimates water quality in the basin to be fairly good.[31] Nonetheless, agriculture and industry can have negative impacts, particularly on water quality in local areas. This includes areas downstream from urban centres such as the Cambodian capital, Phnom Penh, where pollution is greater due to population and industry density, and also areas of water stress that may be vulnerable to the impact on water quantity from upstream water use.

Threats to water quantity from agricultural use are relatively localised; the majority of agricultural land in the MRB is naturally irrigated, and significant expansion of irrigation is likely to be unnecessary for further productivity gains (the MRC expects little expansion in Vietnam and only moderate expansion in Laos, Cambodia and Thailand). Yet irrigation remains a challenge in water-stressed areas of the Mekong basin, such as north-eastern Thailand and north-western Cambodia, particularly during the dry season. In areas like these, it may be possible to achieve more intensive irrigation in the dry season, when it is needed most, and stored water from hydropower development could be part of that solution.[32] However, without proper management, irrigation upstream could threaten water sustainability in areas of the basin that face frequent drought or water stress. Thailand, for instance, has caught the attention of its neighbours in recent years by proposing to divert water out of the basin for

31 MRC. (2010). *State of the Basin Report.*

32 Interview with Robyn Johnston.

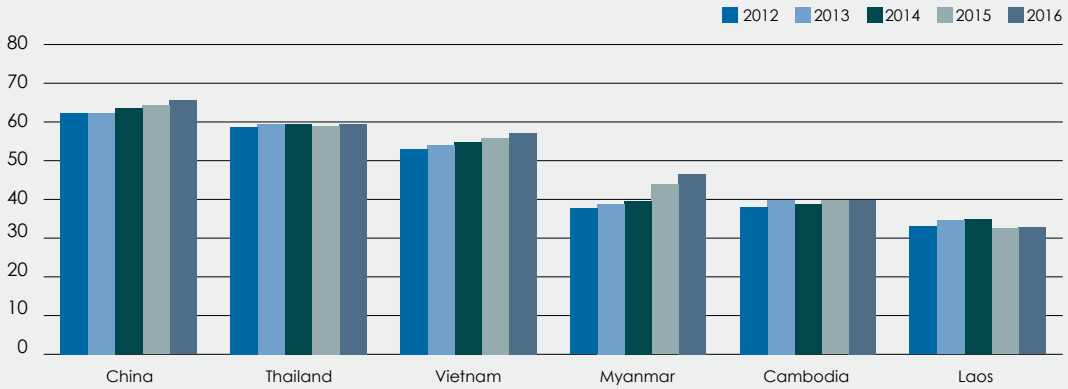
agricultural purposes: other MRB countries fear that this could open the spigot on large water transfers.[33]

Future agricultural and industrial activity may also present challenges to water quality in the MRB. Although water quality in the Mekong is generally considered to be good, the MRC has noted a lack of sufficient research into the impacts of organic pollutants in the basin.[34] The risk of pollution from pesticides and fertiliser may be greatest in Thailand and Vietnam, where these relatively costly inputs are more affordable and widely used. Nonetheless, Laos and Cambodia could face new challenges from inadequate wastewater treatment downstream from urban centres such as Phnom Penh. At present, industrial production in the MRB remains at a relatively low level, given that much of Thailand's and Vietnam's manufacturing is located outside the basin. However, in coming years increased light manufacturing, such as textile production, is likely to become a greater component of the economy of Cambodia, most of which lies within the Mekong basin. Worries over water quality are therefore likely to grow as an area of concern within the MRB.

Threats to food security

As a region that is still combating intense poverty, food insecurity will continue to be a concern in the MRB. Water-resource management could either exacerbate or help to alleviate this problem. Food security in the basin has improved in recent decades as expanded irrigation has raised crop yields, increased the availability of staple foods and reduced the risk of nationwide food crises.[35] However, food security remains a major concern in specific localities in all MRB countries, and particularly in rural areas where poverty is pervasive and vulnerability to natural disasters is high. This includes mountainous regions in northern Laos and Vietnam, Cambodia's north-west and areas around the Tonlé Sap, and also parts of north-eastern Thailand affected by regular drought.[36] Overall, the greatest food security risk in the basin is faced by Cambodia and Laos, where urbanisation is relatively low and the poverty level remains around 20%.[37] Both countries continue to rank well below average in The Economist Intelligence Unit's 2016 Global Food Security Index, which measures the safety, availability and affordability of

Global Food Security Index overall score, 2012-16



Note: A higher value indicates a more favourable environment for food security.
Source: EIU's 2016 Global Food Security Index.

33 Interview with Richard Cronin.
34 MRC. (2010). *State of the Basin Report*.
35 MRC. (2011). *Agriculture and Irrigation Programme: 2011-2015 Programme Document*.
36 Ibid.
37 World Bank.

When water is not abundant: Case study on water, food and energy security in India

It is not accidental that farmers' reliance on surface irrigation (ie, canals) in India diminished substantially—and was replaced with groundwater irrigation (ie, wells)—following the large-scale electrification of rural villages. The access to electricity, energy subsidies and, eventually, affordable pumps that resulted from electrification allowed farmers to engage in groundwater irrigation, which diversified irrigation options and ensured against rain shocks. This switch resulted in improved agricultural yields for small-scale rural farmers.

However, as always, there is a trade-off. By 2011, 61% of irrigated areas in India relied on groundwater irrigation and, as of 2007, more than 70% of the groundwater in India had been consumed.[1] The availability of water resources are under great stress, resulting in questions of agricultural sustainability and long-term food security in the country.[2] This is but one example of water security risks stemming from the energy-water-food nexus in high-water stress countries.

Jyotigram Yojana is an example of a state-led initiative to conserve power and water resources. Availability of power supply for irrigation is restricted to eight hours a day of uninterrupted, full-voltage power, which alternates weekly between day and night, with different cycles in different Indian villages. Balancing out usage reduces the overall cost of generating power, conserves water, maintains irrigation schedules and minimises pump maintenance costs. It has also resulted in an average water level rise in north Gujarat, which before the launch of the initiative was experiencing depletions.[3]

State-led resource management is not the only solution. Precision agriculture, or farm management based on inter- and intra-field crop variability, provides a method of allocating necessary water resources and appropriate energy-driven equipment to crops. Companies are innovating around this resource-efficient agriculture technique: EM3 Agriservices, an India-based farming-as-a-service company, has established a series of agri-service centres across Madhya Pradesh that rent precision agriculture machines, tools and technologies to farmers at affordable prices.[4] This technology-driven solution conserves resources and is a building block for private-sector collaboration to improve water security.

1 Sinha, S et al. (2005). Understanding and Managing the Water–Energy Nexus: Moving Beyond the Energy Debate. *International Water Management Institute*. Available at: http://publications.iwmi.org/pdf/H039320.pdf

2 Sharma, S. (2015). *The political economy of the water-energy nexus in Indian irrigation*. The London School of Economics. Available at: http://blogs.lse.ac.uk/southasia/2015/09/09/the-political-economy-of-the-water-energy-nexus-in-indian-irrigation/

3 Brabeck-Letmathe, P. (2014). *Jyotigram Yojana the new Indian PMs approach towards more sustainable energy and water management*. Nestle. Available at: https://www.water-challenge.com/posts/jyotigram-yojana-%E2%80%93-the-new-indian-pms-approach-towards-more-sustainable-energy-and-water-management

4 Mathew, J. C. (15 January 2017). "A Uber for Agriculture". *Business Today*. Available at: http://www.businesstoday.in/magazine/features/em3-provides-modern-affordable-farm-technology-services-on-a-pay-per-use-basis/story/242968.html

food in 113 countries. Furthermore, by 2050 population growth is expected to increase food demand in the Greater Mekong Subregion by 25% or more, placing an even heavier burden on food systems that are already under stress.[38]

38 USAID. (2013). *Mekong Adaptation and Resilience to Climate Change Synthesis Report*.

Water-resource management in the MRB could impact food security in the region, particularly for poor rural communities. Much of the concern here involves the impact of hydropower development on fisheries, which are a major source of food in the region. In Cambodia, where 75% of the animal protein consumed comes from seafood, the impact of

new dams on fisheries could affect the diet of millions. So too elsewhere in the basin, where capture fisheries and other aquatic animals serve as a food security "safety net" for many poor communities.[39] When the effects of expected improved fisheries management are disregarded, the MRC already estimates that by 2060 capture fisheries production will be significantly lower, and hydropower construction could amplify this trend dramatically.[40] Lack of water infrastructure also contributes to food insecurity in the Mekong basin. Agriculture suffers from underdeveloped irrigation systems in some areas, and water systems remain problematic in poor rural communities—particularly in Laos and Cambodia, where one-quarter of the population still lacks potable water.[41] Ultimately, in seeking to address food insecurity in the region communities will be faced by the continuation of current challenges overlaid with new ones. ■

39 MRC. (2011). *Agriculture and Irrigation Programme: 2011-2015 Programme Document.*

40 MRC. (2016). *IWRM-based Basin Development Strategy 2016-2020.*

41 The Economist Intelligence Unit. (2016). *Global Food Security Index.*

The policy environment: one step forward, one step back

The combined impacts of new development, climate change and intense poverty make for a precarious path to sustained water security in the MRB and point to the importance of effective water governance in the basin. A failure to manage water resources properly could lead to a future in which farmers in the Mekong delta are increasingly affected by drought and saltwater incursion, rural communities in Laos and Cambodia suffer from periods of food insecurity, and communities throughout the region struggle to find livelihood opportunities amid declining productivity in agriculture and fisheries. Alternatively, effective resource management could help to ensure adequate water resources to sustain the food, water and energy needs of communities in the basin. Despite improvements in water management in recent decades, however, further significant improvements are needed.

Inadequate water governance at national level

In the past three decades, MRB countries have gradually put in place the legal, policy and regulatory architecture necessary for effective water-resource management. Since 1999, China's policy of "great westward expansion" has involved harnessing the waterways of the Upper Mekong Basin for economic development: in 2002 it passed a comprehensive national water law consolidating authority over water resources in the hands of the federal government and mandating multipurpose basin-level planning.[42]

In the Lower Mekong Basin, the adoption of national water-governance frameworks has been a gradual process, particularly in the poorest countries. Laos passed its first Water Resources Law in 1996, and in 1999 completed the implementation of language defining the responsibilities of relevant agencies. Cambodia also passed a natural resources management law in 1996, followed a decade later by the 2007 Law on Water Resource Management, which sets out a regulatory and administrative framework for water policy.[43] Vietnam's Law on Water Resources, drafted in 1998, which established policies for water-resource planning and defined rights and administrative authorities with regard to water resources, was ratified in 2012. By 2014 all six Mekong countries had established Environmental Impact Assessment (EIA) procedures—a system for mitigating and remediating environmental damage caused by development activities—as well as water-resource management committees with representation from relevant national ministries.[44] The water-resources policy development process is ongoing: since 2015, Cambodia, Vietnam and Myanmar have

42 Yuen-ching, B.L. (2013). "Water Power: The 'Hydropower Discourse' of China in an Age of Environmental Sustainability". *ASIANetwork Exchange*, Vol. 21, No. 1.

43 International Union for Conservation of Nature. (2009). *Water Governance: A Situation Analysis of Cambodia, Lao PDF and Vietnam.*

44 Baird, M.; Frankel, R. (2015). Pact. *Mekong EIA Briefing: Environmental Impact Analysis Comparative Analysis in Lower Mekong Countries.*

"In Cambodia, it may be the case that several departments—industry, agriculture, health—will each conduct their own water quality measurements with little co-ordination."

Robyn Johnston, IWMI

each made further improvements to water-related policies and regulations, often with the aim of clarifying administrative responsibilities and regulatory procedures.[45]

However, even with new water laws on the books, national water governance in these countries remains hampered by inefficient bureaucracies and inadequate implementation procedures. Poor co-ordination among government departments is particularly problematic, with water-resource management often fragmented across different ministries and offices. "In Cambodia, it may be the case that several departments—industry, agriculture, health—will each conduct their own water quality measurements with little co-ordination," says Robyn Johnston of the IWMI. While one department may be responsible for irrigation projects, Ms Johnston adds, another may be responsible for large canal works, and there will be little communication between the two. Water-related regulations—such as EIA procedures—are another weak point in governments' efforts to address the stresses of new development. "Despite generally sound laws, the EIA in the region is seen more as an administrative requirement than an excellent tool to improve project design," according to Peter King, an expert on EIAs in the Mekong region and former director of Pacific Operations for the Asian Development Bank (ADB). In general across the region, public participation in EIA procedures is encouraged but not mandated, grievance mechanisms are often lacking and public access to EIA reports is poor.[46]

Poor planning and management at the national level has also limited the capacity of governments to pursue climate adaptation efforts that would improve water security by mitigating the effects of drought and saltwater intrusion on agriculture. Climate change is on national agendas: with the exception of Myanmar, all of the MRB countries have adopted national climate-change strategies and submitted national climate plans in advance of the UN's 2015 Climate Change Conference (known as COP21) in the French capital, Paris. Furthermore, climate-change budgets in the Lower Mekong Basin have been noteworthy in recent years. In 2011, for example, Cambodia and Thailand dedicated 3.6% and 2.7% of their national budgets respectively to addressing climate change.[47] However, management leaves much to be desired, and national efforts show evidence of poor prioritisation and a lack of transparency. The climate-change plans of Cambodia and Laos each identified around US$1bn in needs over five years, but the rationale for these figures is unclear. Furthermore, at the ministry level many of these adaptation strategies have not been integrated into work plans, and there is evidence that projects have been poorly prioritised. One study found that between 20% and 60% of climate-related projects in the MRB in 2011 were of little relevance to climate change and that they often funnelled funds to "hard" infrastructure projects rather than "soft" approaches, such as improved agricultural practices, that could improve water and food security.

Regional water governance faces an uncertain future

The most important development in water governance at the regional level has been the establishment of the 1995 Mekong Agreement between Vietnam, Cambodia, Laos and Thailand. The agreement was designed to ensure the equitable and reasonable use of water and water-related resources in the MRB for all countries in the region, and remains the only international

45 Interview with Peter King.

46 Baird, M.; Frankel, R. (2015). Pact. *Mekong EIA Briefing: Environmental Impact Analysis Comparative Analysis in Lower Mekong Countries.*

47 USAID. (2016). *Harnessing Climate Finance for Rural Adaptation in the Lower Mekong Basin: Opportunities, Constraints, Future Prospects.*

IN FOCUS: Additional regional frameworks

Countries in the Mekong River Basin (MRB) are party to several additional international agreements relevant to water security. All countries in the basin except Myanmar are signatories to the Rotterdam Convention and the Stockholm Convention, which regulate the trade and use of hazardous chemicals and pesticides that can pollute waterways, as well as the Basel Convention, which covers the management and disposal of hazardous waste. Other international agreements provide a platform for improving access to water and sanitation in the wake of natural disasters in the region. In 2009 members of the Association of South-East Asian Nations (ASEAN) implemented the Agreement on Disaster Management and Emergency Response (AADMER), inspired in part by the 2004 Indian Ocean tsunami. The AADMER agreement, to which all MRB countries are party, promotes collaboration in response to major natural disasters, such as floods and major storm events, and encourages steps to alleviate immediate threats related to sanitation in the aftermath of such disasters.

agreement for the management of water in the basin. In some ways the Mekong Agreement was ahead of its time. It was modelled on a draft of the 1997 UN Watercourses Convention (UNWC), which set out rules for the sharing of transboundary waters (as of 2016, the UNWC has been signed by only 36 countries).[48] The Mekong Agreement sought to apply the principles of international law to water resources in the Mekong basin through institutions that reflected the signatories' shared reliance on the Mekong river and anticipated future threats to water security.

One of the key features of the Mekong Agreement was the establishment of the Mekong River Commission (MRC) to help countries in the basin to "co-operate in all fields of sustainable development, utilisation, management and conservation of the water and related resources of the Mekong River Basin."[49] Besides creating a foundation of research for national governments' use, the MRC has the notable function of helping to co-ordinate the planning of projects with basin-wide impact, such as new hydropower dams. This includes administering the Procedures for Notification, Prior Consultation and Agreement (PNPCA). The PNPCA are designed for reviewing the impacts of major projects along the Mekong and enabling agreement on mitigation measures. They require MRC countries to bring new mainstream projects before member countries for review and discussion—this includes any major project, such as large-scale water diversions or hydropower projects. The purpose is to facilitate consensus on controversial mainstream projects.[50] MRC member countries are thereby provided with a forum to raise concerns about projects and participate in a dialogue aimed at achieving consensual solutions.

However, since 2011 the co-ordinating function of the MRC has proved ill equipped to mediate disagreements among countries over major new hydropower projects; MRB countries have no power to veto projects under the PNPCA. Laos' first two dam projects have demonstrated the flaws in this arrangement. In 2011 that country's government initiated the process for its proposed Xayaburi dam, and three years later the project was given the go-ahead by the Lao government, despite objections from

48 Vietnam is the Mekong River Basin's only signatory to the UNWC.
49 Mekong Agreement, Article 2.
50 Hydropower projects on tributaries are not subject to review under the PNPCA.

Cambodia and Vietnam.[51] The process was further undermined in 2013, when Laos determined—against the judgment of the MRC—that the Don Sahong dam did not warrant review under the PNPCA due to its location, and the MRC proved unable to force the Lao government to submit the scheme to a review.[52] With more dam proposals on the horizon, the effectiveness of the PNPCA has been put in doubt. "The MRC has announced a review of the PNPCA, stating that lessons learned from Xayaburi and Don Sahong will inform the process," says Maureen Harris of International Rivers. "But no further information has been made available as to the process or status of the review." The government of Laos meanwhile notified the MRC in November 2016 of its intention to develop yet another dam, at Pak Beng. "The prior-consultation process is imminent," says Ms Harris, "with little expectation of an improved process this time around."

In coming decades, water insecurity is likely to pose an increasing threat to communities in the MRB if leaders fail to address shortcomings in national and regional frameworks for water governance. At the national level, governments will need to further clarify and develop the capacity of relevant ministries to address threats, through improved EIA procedures, better co-ordination among ministries and more clearly articulated climate adaptation plans. At the regional level, countries in the MRB need effective mechanisms for addressing transboundary water issues and the negative impacts of new hydropower developments. More generally, however, the region would benefit from basin-wide integrated water-resources management (IWRM)—the co-ordinated development and management of water-related resources to achieve efficient, equitable and sustainable use by upstream and downstream stakeholders.[53] Without procedures for making collaborative decisions about water use and transboundary impacts, the Mekong basin could well face unintended trade-offs with great economic and environmental costs. ■

51 Cronin, R.; Weatherby, C. (2015). Stimson Center. *Letters from the Mekong: Site Visit to Laos' First Two Mainstream Dam Projects.*

52 The Don Sahong dam project was later submitted for review following diplomatic pressure.

53 MRC. (2010). *Mekong Integrated Water Resources Management Projection Inception Report.*

The status of collaborative efforts in the Mekong River Basin

"Particularly in Vietnam and Thailand, the NMCs [National Mekong Committees] are dwarfed by influential ministries with a mandate over water policy. Without buy-in from the proper ministries, the MRC can only be so effective."

Robyn Johnston, IWMI.

Collaboration among key actors in the MRB has been a mixed bag, with notable failures often overshadowing smaller, but important, successes. Despite setbacks to regional co-operation on hydropower development, the MRB enjoys relatively strong support from the international community. Donors and multilateral institutions have pledged billions of dollars in aid and loans for the Mekong region through a variety of channels, in many cases to improve infrastructure in order to facilitate economic development and to finance climate adaptation measures. While not all efforts at collaboration have been sufficient to address the challenges outlined so far, collaboration has in many cases been integral to improving water security in the region. Taking inventory of these successes and failures could help countries in the MRB and elsewhere to identify pathways towards energy, food and water security in the decades to come.

Troubled waters: The future role of the Mekong River Commission

The most important institution for collaboration within the MRB has been the Mekong River Commission (MRC), which, despite its failures, plays a critical function in implementing the PNPCA and serves as an important research and co-ordinating body. Traditionally, the MRC's work has spanned a dozen programme areas—including agriculture and irrigation, drought, environment, fisheries, navigation, climate change, and hydropower—and its research is deployed at the national level through the co-ordinating action of the UN-affiliated Mekong Committee and the National Mekong Committees (NMCs) in each country.[54]

"The research function of the MRC has been very important," says Robyn Johnston of the IWMI. "For instance, it has done a lot to reassess and articulate the important economic value of fisheries in the basin, now estimated at around US$17bn annually." Yet the MRC has proved less robust in other ways: while it has historically been successful in engaging the international community in water management, it has long struggled to enlist national governments in its programme work. "Particularly in Vietnam and Thailand, the NMCs are dwarfed by influential ministries with a mandate over water policy," says Ms Johnston. "Without buy-in from the proper ministries, the MRC can only be so effective." Added to this is the recent failure of the PNPCA to address stakeholder concerns over hydropower development. This has reduced enthusiasm for the institution in recent years, leading to donor disengagement and significant cuts to the MRC's budget.[55] [56]

54 The MRC's 2016-2020 Strategic Plan involves phasing out its previous programme structure. The 12 programme areas have traditionally been: agriculture and irrigation; basin development plan; climate change and adaptation initiatives; drought management; environment; fisheries; flood management and mitigation; information and knowledge management; initiatives on sustainable hydropower; integrated capacity-building; Mekong integrated water-resource management; and navigation.

55 Interview with Richard Cronin.

56 In November 2016 the MRC announced that the government of Norway would provide US$5.3m to support the MRC's work in four areas identified in the MRC Strategic Plan 2016-2020.

"…so far there is little evidence that the new Chinese regional framework will improve upon the existing MRC framework for collaboration within the basin, for the simple reason that China refuses to compromise on its ability to regulate the river in its own self-interest or for the sake of co-operation on sustainable and equitable sharing of a common resource."

Dr Richard Cronin, the Stimson Center

These developments have shifted attention toward the possibility of new or additional forms of collaboration on water security within the MRB. For example, in 2014 China announced the Lancang-Mekong Co-operation Framework, an alternative platform for collaboration among governments. The MRC continues to struggle owing to the non-participation of China, which has been the largest developer of hydropower in the Mekong basin and has already built a cascade of hydropower projects on the upper reaches of the Mekong river. The Lancang-Mekong Co-operation Framework proposal remains in the early stages of development, and China has provided few details indicating whether the framework will complement or compete with the MRC as a focus for collaboration.[57] The Chinese framework could feasibly improve co-operation among countries if it achieves buy-in at the national level from the appropriate ministries. However, observers are sceptical. "There is certainly need for greater collaboration on water security in the Mekong basin," says Richard Cronin of the Stimson Center, a think-tank based in the US capital, Washington, D.C. "However, so far there is little evidence that the new Chinese regional framework will improve upon the existing MRC framework for collaboration within the basin, for the simple reason that China refuses to compromise on its ability to regulate the river in its own self-interest or for the sake of co-operation on sustainable and equitable sharing of a common resource." Instead, Dr Cronin has suggested that the MRC will continue to play an important role as a platform for research and dialogue on resource management in the basin, supported by other forms of multilateral and bilateral co-operation.

Third parties and further platforms for the promotion of water security

While the MRC works to reaffirm its relevance, a number of other institutions will also continue to serve as important platforms for collaboration among donors, governments, NGOs and private companies, in many cases addressing water security by focusing on infrastructure, energy, agriculture and other areas of economic development. In 1992 the ADB established the Greater Mekong Subregion (GMS) Programme, in an effort to enhance economic development and co-operation among the six MRB countries. This has included the development of energy infrastructure (including hydropower) and has so far facilitated US$11bn in infrastructure projects. The GMS framework also includes working groups on agriculture and the environment, bringing together senior government officials from the relevant ministry in each country. Meanwhile, the Lower Mekong Initiative (LMI), launched in 2009, is a partnership between the US and the five countries of the Lower Mekong Basin to facilitate and advance subregional co-operation.[58] It has included technical assistance to the MRC on sustainable fisheries and aquaculture, climate-change adaptation programmes, stakeholder engagement and donor co-ordination.[59] Unlike the GMS framework, the newer LMI is more narrowly focused on water security in the Mekong basin. For instance, it has supported infrastructure improvements through a Smart Infrastructure for the Mekong (SIM) programme providing technical assistance to governments on infrastructure and water-resource management.

NGOs, too, have played an important role in supporting improved governance and

57 Ministry of Foreign Affairs of the People's Republic of China. (2016). *Five Features of Lancang-Mekong River Co-operation*. Accessible at: http://www.fmprc.gov.cn/mfa_eng/zxxx_662805/t1349239.shtml

58 Lower Mekong Initiative. Accessible at: http://www.lowermekong.org/pillar/environment-and-water/projects-and-activities/environment-and-water-pillar

59 Ibid.

stakeholder involvement relevant to water security, and will continue to do so. National networks such as the Rivers Coalition in Cambodia and the Vietnam Rivers Network have played an important role engaging local communities in discussions surrounding hydropower in the MRB.[60] International NGOs can also help to engage and inform stakeholders. For example, in 2012, through its Challenge Programme on Water and Food Innovation Fund, the CGIAR consortium (an international research partnership focused on food security and poverty alleviation) arranged for government officials and NGO workers from Cambodia to visit one of Laos' dam expansion projects as a capacity-building measure to enable more effective engagement and evaluation of hydropower projects.[61]

Beyond transboundary water issues, non-government actors can also help to improve local and national water governance. For example, the International Union for Conservation of Nature has sought to improve water governance at national level in the MRB through its Mekong Region Water Dialogue Programme and, more recently, its Building River Dialogue and Governance Programme (BRIDGE). The latter initiative has focused on working to connect MRC principles concerning water governance to those of the UN. Meanwhile, still other organisations, such as the Asian Disaster Preparedness Centre, have helped to advance community-based disaster risk reduction efforts in the basin.[62] Private foundations—such as the McKnight Foundation, the MacArthur Foundation, the Gates Foundation and the Coca-Cola Foundation—have funded stand-alone sector-focused activities in the MRB through grants in the US$100,000-300,000 range, often targeted at river conservation, water storage, fisheries and other water-related activities.[63]

The private sector has an important role to play as well, both at the policy level and also through support for programmes and innovations that improve water security. Since 2013, the International Finance Corporation (IFC), the private-sector financing arm of the World Bank, has worked with the Lao Chamber of Commerce to establish the Hydropower Developers Working Group (HDWG) to engage hydropower companies in policy discussions in the Mekong basin. Through the HDWG, which is envisioned to eventually become a stand-alone trade association, developers have advocated the clarification of relevant laws and regulations that they say remain poorly defined under current law, such as the approval process for small dam projects. Beyond hydropower, private-sector collaboration will also prove important because of the massive investments required to reduce poverty and protect water resources. The UN has estimated a global US$2.5trn funding shortfall to reach its Sustainable Development Goals for addressing food security, climate change, infrastructure and other projects, and the private sector could play an important role in closing this gap.[64] To date, private-sector collaboration in the MRB has occurred largely through relatively conventional avenues such as investment in infrastructure, technology transfers and corporate social responsibility. However, more could be done to ensure that supply chains reinforce, rather than threaten, water security at the local and regional levels.

The experiences of several multinational companies engaged in food manufacturing help to illustrate the private sector's contribution to water security in the MRB. For

60 Interview with Maureen Harris.

61 CGIAR Research Programme on Water. (2012). *Learning from Laos: Hydropower Development and Affected Communities.* Accessible at: http://wle-mekong.cgiar.org/learning-from-laos-hydropower-development-and-affected-communities/

62 Polack, E. (2010). Institute for Development Studies. *Integrating Climate Change into Regional Disaster Risk Management at the Mekong River Commission.*

63 USAID. (2016). *Harnessing Climate Finance for Rural Adaptation in the Lower Mekong Basin: Opportunities, Constraints, Future Prospects.*

64 UN Conference on Trade and Development (UNCTAD). (2014). *World Investment Report.*

example, beverage companies requiring water resources to produce their goods have a stake in preventing harm—and the perception of harm—to these resources. In 2008, Coca-Cola formed a partnership with the World Wildlife Federation to support its work in the Mekong region as part of its Global Water Stewardship programme to protect water resources.[65] In Vietnam, two companies, Cadbury and Cargill, have partnered with regional agricultural departments to invest in technology transfer centres to support new cocoa production in the country.[66] Still other firms are taking steps to ensure responsible production and consumption by establishing sustainable value chains. For example, the WalMart Foundation has made grants to the Sustainable Fisheries Partnership to improve and expand aquaculture techniques in Thailand as part of its goal of sourcing 100%-sustainable, third-party-certified seafood.[67] But these approaches will need to be applied more extensively, and by a greater number of private companies, in order to ensure that value chains in the MRB reinforce water security. ■

65 Sheppard, K. (2012). *Mother Jones*. "Why Does Coke Care about the Mekong Delta?"

66 Vietnam News. (2014). "Farmers Helped to Increase Cocoa Yield".

67 Sustainable Fisheries Partnership. (2015). "Walmart Foundation and SFP Announce Aquaculture Improvement Projects in Indonesia, China, and Thailand". Accessible at: https://www.sustainablefish.org/News/Walmart-Foundation-and-SFP-Announce-Aquaculture-Improvement-Projects-in-Indonesia-China-and-Thailand

The promise of technology and innovation

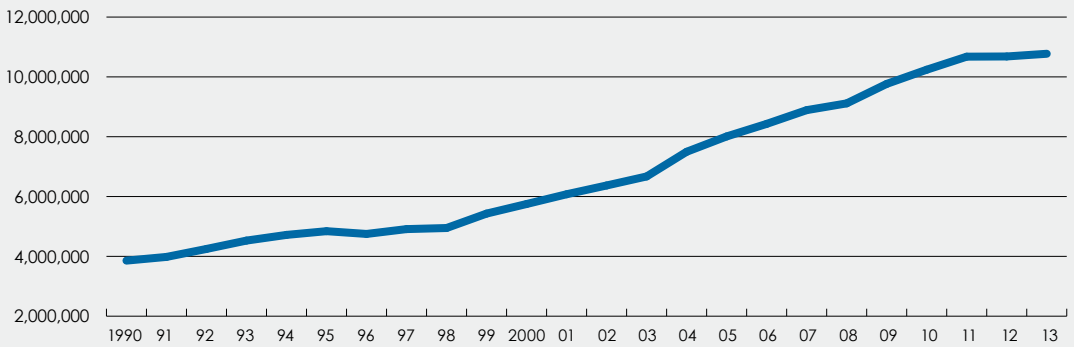
The greatest challenges to water security in the MRB will require policy solutions. However, continued innovation can also play an important role in addressing these issues. In particular, local innovations in agricultural practices are playing a part in combating food insecurity and preventing costly damage from natural disasters. Some of the most promising innovations include adjusting cropping seasons; reducing water use through alternate wetting and drying; fertiliser management; and the development of rice varieties with greater tolerance for drought, pests, salinity and acidity. In many cases donors, NGOs and private companies have collaborated with local farmers to employ novel approaches to climate-change adaptation. Many of these new approaches simultaneously play an important role in fighting food insecurity, by preventing disruptions to food systems and ensuring the security of livelihoods. While many of these innovations show promise, however, in many cases they will require further support and scaling up in order to have a broader effect on the massive challenges facing the region.

Improved productivity in agriculture and fisheries

In the MRB, history suggests that technology and innovation in agriculture and fisheries can have a transformative impact on communities. One illustration of this involves the introduction of genetically improved farmed tilapia (GIFT) in the 1990s with support from the ADB. Tilapia had long been farmed in the Mekong basin, but in the late 1980s and early 1990s the ADB provided technical assistance to support the research, development and distribution of more robust

Fish production in the Mekong River Basin (excluding China), 1990-2013

Total production of fish, by year, tonnes



Note: Sum of demersal fish, freshwater fish, marine fish (other), pelagic fish.
Source: Food and Agriculture Organization of the United Nations.

"Policymakers are interested in AWD because it can save irrigation water, increase the profit of farmers and mitigate greenhouse gas emissions."

Dr Bjoern Ole Sander, IRRI

tilapia. Through conventional methods involving selective breeding, freshwater Nile tilapia were used to produce more robust varieties that matured in a relatively brief 4-6 months and reached a higher weight at harvest.[68] The result of this innovation was to allow up to three fish crops per year as well as to reduce reliance on inputs such as expensive commercial feeds. By 2003 GIFT or derivative strains accounted for 17% of tilapia seed in Vietnam and 46% in Thailand, and the ADB estimates that the innovation has contributed significantly to improved food security and employment in fisheries in the region.

Similarly, recent innovations in agriculture have begun to contribute to improved climate adaptation, more stable livelihoods and increased water security. A number of these changes focus on rice production, in part because of its ubiquity in the MRB and its vulnerability to natural disasters. An important proponent of agricultural innovation is the International Rice Research Institute (IRRI), a research and education centre based in the Philippines. IRRI's work focuses on food security and climate adaptation, and in 2002 it established the Consortium for Unfavorable Rice Environments (CURE) with funding from the International Fund for Agricultural Development in order to explore solutions for countries with unconducive rice-growing conditions. In Laos, for example, CURE has worked with farmers—particularly in upland areas with lower and more variable rainfall—to improve rice yields and establish more stable production through the introduction of seed banks.[69]

In the Mekong delta, a major challenge to rice production is late-season saltwater intrusions that can damage crops—a problem that can be exacerbated both by rising sea levels and by increased upstream water use that reduces freshwater flows. One innovative response has been the development of improved varieties with shorter growth duration. These are capable of maturing before saltwater intrusion occurs, thereby protecting yields late in the season.[70] This approach also allows farmers to fit in more growing seasons or longer fallow periods to conserve water. "A shorter season can also amount to significant water savings, simply because the flooding period of the rice is not as long," explains Bjoern Ole Sander, a scientist and climate-change expert at IRRI. As another means of adapting to saltwater intrusion, IRRI is collaborating with the Cuu Long Delta Rice Research Institute to cultivate new salinity-tolerant rice varieties that are better adapted to withstand salinity at the seedling and maturity stages, when rice is vulnerable. Many rice varieties farmed in the delta have a maximum salinity tolerance of 5%; increasing this tolerance could improve the viability of rice crops late in the season, when saltwater intrusion is most severe.[71]

Particularly in Vietnam, reduced water consumption can also be achieved through alternate wetting and drying (AWD) techniques for rice production. "Policymakers are interested in AWD because it can save irrigation water, increase the profit of farmers and mitigate greenhouse gas emissions," says IRRI's Dr Sander. AWD employs relatively simple tools to ensure that a rice field is allowed to drain to near-dry for several days before irrigation is reapplied. When properly applied, it can enable rice production under more drought-prone conditions; however, it can also have a more immediate impact on profitability, as it allows farmers to reduce the number of hours during which pumps are used for irrigation, thereby lowering their fuel and

68 ADB. (2005). *An Impact Evaluation of the Development of Genetically Improved Farmed Tilapia*.

69 Consortium for Unfavorable Rice Environments. (2012). "Training of Trainers on Community Seed Banks for Upland Rice Held in Laos". *CURE Matters*, Vol. 2, No. 1.

70 Australian Centre for International Agricultural Research. (2016). *Final Report: Climate Change Affecting Land Use in the Mekong Delta: Adaptation of Rice-based Cropping Systems (CLUES)*.

71 USAID. (2016). *Development of Rice-Shrimp Farming in the Mekong River Delta, Vietnam.*

"Good water management will require a regional strategy that both saves water upstream and also sustains freshwater flows downstream so that salinity is pushed out of the delta."

Dr Bjoern Ole Sander, IRRI

labour costs. IRRI estimates that AWD can reduce water use by 30%, and a 2015 study suggests that it could realise an increase in net returns of 9-38% over continuously flooded rice fields.[72] In Vietnam's northern An Giang province IRRI has worked with the Ministry of Agriculture and Rural Development to increase AWD uptake, and the system has also been field-tested in areas in Laos and Myanmar. In 2011, Vietnam's agriculture and rural development ministry set the goal of adopting AWD in 3.2m ha of rice paddy by 2020.

However, realising the full potential of agricultural innovations requires the right conditions as well as effective collaboration and scaling, which can be challenging in the MRB. Some innovations have often been applied more extensively in Vietnam than Laos or Cambodia, in part because Vietnam has been a darling of the development world. But techniques such as AWD also require proper conditions, such as flat fields conducive to draining and good water systems that allow for the control of water flow.[73] This is often feasible in regions of Vietnam or Thailand that have developed irrigation systems, but it is more challenging in areas of Laos, Cambodia and Myanmar that rely on rain-fed systems. Such difficulties may be manageable, and IRRI is currently using remote sensing and geospatial mapping to develop new techniques for identifying areas suitable for AWD. However, as Dr Sander points out, even in Vietnam co-ordination and planning is required to achieve the full benefit of these technologies. "Good water management will require a regional strategy that both saves water upstream and also sustains freshwater flows downstream so that salinity is pushed out of the delta."

These challenges notwithstanding, agricultural practices with demonstrated economic or environmental benefits have been scaled up successfully in the MRB with the support of governments and development partners. For example, in recent years USAID has lent its efforts to researching and expanding rice-shrimp production—a method that involves rice cultivation during the rainy season when salinity is low and shrimp production at other times—in the Mekong delta.[74] It is a lucrative technique that has been common in coastal areas of Vietnam since the 1970s but expanded from 71,000 ha to 152,000 ha between 2000 and 2014.[75] Vietnam's agriculture and rural development ministry estimates that the industry could exceed US$1bn in annual value by 2030. Similar support for innovations that improve water availability and climate adaptation could have a dramatic impact on water security throughout the region.

Innovations in data application

In recent years there has also been a growing trend towards leveraging data collection in the MRB to improve agricultural practices and enhance water-related climate adaptation measures. This has generally involved extensive collaboration between research institutes, donors, government ministries and the private sector. The most prominent examples include the use of satellite imagery and geospatial technology to reduce the risk of food insecurity and economic losses due to natural disasters. In 2014, USAID, NASA and the Asian Disaster Preparedness Centre collaborated in launching the five-year SERVIR-Mekong programme to help MRB countries to utilise satellite imagery for the purposes of land-use planning, infrastructure development and disaster risk management. SERVIR-Mekong works in partnership with

72 Lampayan, R.M.; Rejesus, R.M.; Singleton, G.R.; Bouman, B.A.M. (2015). "Adoption and economics of alternate wetting and drying water management for irrigated lowland rice." *Field Crops Research* 170: 95-108.

73 Interview with Robyn Johnston.

74 USAID. (2016). *Development of Rice-Shrimp Farming in the Mekong River Delta, Vietnam.*

75 Ibid.

"Fish passage technologies being used in dams that are now under construction are untested in the context of the Mekong—including the sheer volume and species of fish, and many fisheries experts have expressed serious doubts that they will work."

Maureen Harris, International Rivers

businesses and public institutions to use publicly available satellite imagery for disaster response, resource management and food-security efforts. Since its launch, the project has developed tools for surface-water mapping, land-cover monitoring, and for forecasting drought and crop yield.[76] By combining satellite data with interviews with government officials and other stakeholders, SERVIR-Mekong has conducted geospatial data needs assessments of the five Lower Mekong Basin countries, which could facilitate improved water-resource management.[77]

Satellite imagery is also being used to enable the private sector to provide financial instruments that reduce the financial risks that farmers face. Crop insurance plans in the MRB have gained greater attention from donors in the past decade. In Vietnam's delta and central highlands, for instance, the Ford Foundation and the ADB have supported efforts to develop crop insurance schemes aimed at coffee and rice production. Beginning in 2011, a German financial services provider, the Allianz Group, partnered with IRRI and the German agency for international development (GIZ) to improve microinsurance provision to farmers by using satellite imagery to forecast rice production more accurately. Under the RIICE (Remote sensing-based Information and Insurance for Crops in Emerging economies) programme, Allianz provides insurance to governments and local insurers in Cambodia, Laos and Vietnam, which in turn offer microinsurance to farmers. The satellite-based remote sensing used by RIICE to map rice cultivation and estimate yield can also be used to target food-security programmes and co-ordinate relief efforts in the wake of natural disasters such as droughts and flooding.

Innovations in energy infrastructure and consumer products

Given the drive toward hydropower production in the MRB, it is also conceivable that water security in the region could be bolstered by innovations in energy production. To date, discussion has focused largely on innovations that reduce the negative impacts of dams on the Mekong mainstream. For instance, concerns about the Xayaburi and Don Sahong dams raised through the MRC's PNPCA process inspired hydropower developers to spend millions of dollars researching and installing new technologies to improve fish-lifts, bypass systems and switchbacks to accommodate fish traffic on the river.[78] However, these innovations remain costly and unproven: "Fish passage technologies being used in dams that are now under construction are untested in the context of the Mekong—including the sheer volume and species of fish," says Maureen Harris of International Rivers, "and many fisheries experts have expressed serious doubts that they will work." Furthermore, the positive effect of such technologies may be greatly reduced as a result of the compounded impact of multiple dams. Ultimately, such innovations may achieve little more than to preserve a core breeding stock of certain fish.

Richard Cronin of the Stimson Center and others have suggested that investment in energy infrastructure, in the form of the development of a national electricity grid in Laos for the transfer of power between northern and southern Laos, could support renewable energy in the Lower Mekong Basin. The proposal, which has support from the ADB, could reduce the need for further mainstream dams on the Mekong river by networking tributary dams and enabling the development of renewable energy sources such as wind

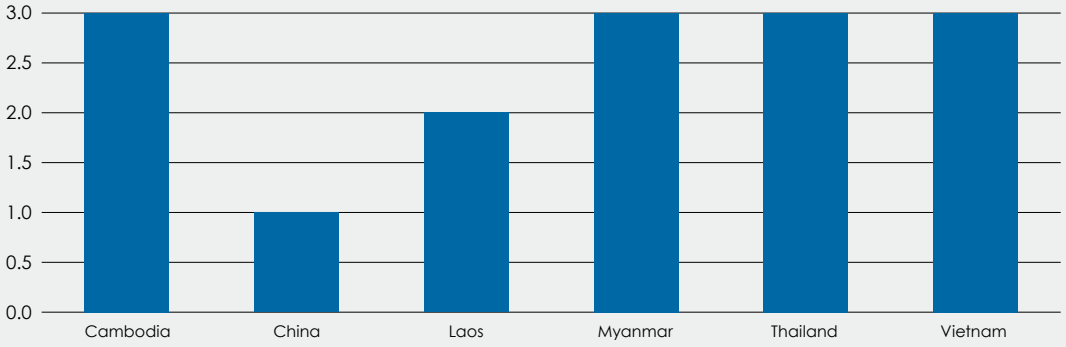
76 USAID. (2016). SERVIR-Mekong. Accessible at: https://www.usaid.gov/asia-regional/fact-sheets/servir-mekong

77 Ibid.

78 Cronin, R.; Weatherby, C. (2015). Stimson Center. *Letters from the Mekong: Site Visit to Laos' First Two Mainstream Dam Projects.*

Quality of the power network, Mekong River Basin

Risk that the power network is insufficient to support business operations



Note: Scored 0-4, where 4 = most risky.
Source: EIU Risk Briefing.

"Laos could get the same net revenue with fewer dams if it had a grid."

Dr Richard Cronin, the Stimson Center

and solar power.[79] Supporters say that such a scheme could be economically fruitful without the negative impacts of mainstream dams. Dr Cronin argues that "Laos could get the same net revenue with fewer dams if it had a grid." On the one hand, its current lack of a national grid causes Laos to sell cheap, base-load electricity to Thailand in the north of the country and purchase more expensive peaking power from Thailand in the south. A national grid would also allow Laos to exploit more readily its solar and wind energy potential. The country is currently exploring a power purchase agreement with Thailand for a 600-MW wind farm in south-eastern Laos that would be the largest in ASEAN, but without a domestic power grid the electricity produced there would go to Thailand. A national grid could facilitate electricity transfers within Laos and reduce the need to construct further dams such as the large Pak Beng and Pak Lay projects in the north of the country, which would be the next two dams to be built after Xayaburi and Don Sahong. Yet such proposals have so far failed to compete with the allure of the large revenue streams that hydropower exports purport to offer the government of Laos.

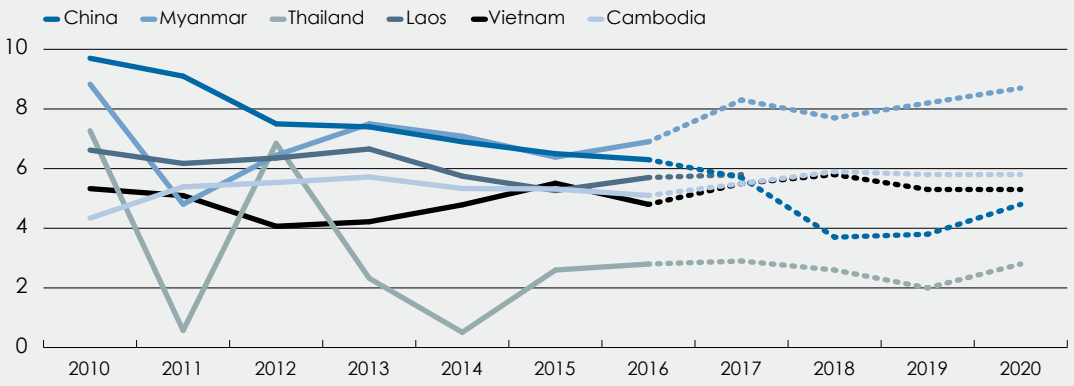
In a rather different way, innovations in household-level consumer products could also impact water security in the MRB by helping to address water use and pollution in growing urban centres. Poverty remains high in the MRB, yet by 2030 MRB countries will see growth in GDP per capita fuel increased consumer spending, particularly among working-age consumers in urban areas.[80] Against this backdrop, consumption habits and innovative consumer products can also play a part in improving water security, most of all downstream from urban centres. For example, in 2007 the British-Dutch consumer-goods company, Unilever, partnered with Vietnam's Ministry of Natural Resources to market and distribute a fabric softener that required fewer rinses and which thereby reduced water use by 75% when doing laundry.[81] Within two years of introducing the product, Unilever had proved the existence of a market for more sustainable consumer products and influenced several competitors to follow suit; the company's product played a role in reducing water consumption, in addition to cutting the labour and time that

79 Ibid.

80 McKinsey Global Institute. (2016). *Urban World: The Global Consumers to Watch.*

81 Reddy, S.K. (2015). "Rinse, But no Need to Repeat". *Asian Management Insights,* Vol. 2, Issue 1.

GDP per capita growth
(% change per year)



Source: The Economist Intelligence Unit.

households spend on laundering clothes. As disposable income rises, providers of consumer products will have an increasing impact on water security in the MRB, particularly if they can design products that transform markets and consumer behaviour in ways that improve water security in the region. ■

Conclusion: slow but steady progress towards water security

Communities in the Mekong River Basin (MRB) continue to face major barriers to water security, and not all efforts to address these challenges have proved successful. In coming years, new development—particularly hydropower energy production—is likely to have a negative impact on fisheries and agriculture, straining livelihoods and testing relations between countries in the region. The visionary 1995 Mekong Agreement has proved ill equipped to moderate such disagreements. As Laos proceeds with new dam construction, critics remain dissatisfied with efforts by hydropower developers to mitigate environmental and social risks. At the same time that transboundary water planning has floundered, national governments in the Mekong basin continue to struggle to institute effective bureaucracies and governance frameworks at the national level to prevent and mitigate the negative effects of agricultural, urban and industrial growth. Meanwhile, the effects of natural disasters and climate change only compound these concerns, as countries in the basin continue to suffer costly water-related natural disasters and face increasing need for comprehensive and strategic national plans for climate adaptation.

However, several steps have proved fruitful in improving water security in the Mekong basin. Despite the shortcomings of the PNPCA, the MRC remains an important platform for basin-wide dialogue, and globally it remains a unique institution in terms of scope and scale. Besides providing a forum for stakeholders to voice concerns about the direction of water-resource management in the region, the MRC has conducted valuable research on a variety of water-related topics and has helped to co-ordinate the development efforts and climate adaptation measures of member countries. Utilising this research, other actors—including development partners, NGOs and private companies—have also collaborated with governments via a variety of platforms to address water-security challenges in the basin. In particular, they have proved successful in generating innovative solutions that mitigate the impact of climate change on the Mekong basin's water resources and the livelihoods that they support. If properly scaled up, interventions aimed at improving agricultural productivity and resilience could help to reduce the threat of natural disasters in the MRB and further improve both water and food security for future generations.

As a region that is generally rich in water, the MRB provides a useful illustration to the rest of the world of both the interconnectedness of water users and, importantly, the intersection of water security, energy security and food security. Events in the basin demonstrate the trade-offs implicit in decisions about how to utilise this unique shared resource. However, experiences in the Mekong basin also suggest that effective water governance, combined with successful efforts to leverage third-party collaboration and innovation, may help governments to minimise multiple threats to social and

economic wellbeing and maximise the benefits that can be gained from this natural resource. While many regions of the world—such as Central and South Asia, and also the Middle East—face far greater water scarcity, they share with the MRB the challenge of balancing the various priorities that interact at the food-water-energy nexus. Ultimately, water abundance is no substitute for good water governance, and countries the world over face similar challenges in terms of ensuring water security. In the Mekong basin, water governance will remain a work in progress, but the understanding of water-resource management has already taken important steps forward. ■

Water security lessons from the Mekong River Basin

Challenge	Region	Innovation	Potential solution(s)
Competing uses of water (eg, Food-energy-water trade-offs)	Global	• Technologies for conserving water (eg, AWD) • Hydropower as an irrigation source	• Collaboration amongst stakeholders • Issue awareness • Balancing trade-offs
Hydropower disruptions	Major river basins, for example: • Amazon River Basin • Columbia River Basin • Mekong River Basin • Nile River Basin	• Fish passage technologies (require proof) • Alternative energy sources and power grid improvements	• Regional planning • Collaboration amongst stakeholders • Awareness of the food-energy-water nexus and ecosystem dependence
Climate change vulnerability	Global, but especially: • Southeast Asia • Sub-Saharan Africa • Latin America • Middle East and North Africa	• Technologies for climate change mitigation and adaptation • Better flood, drought and other water-related disaster management (eg, Canals, water-resistant or drought-resistant crops)	• Commitment to technology and innovative solutions • Commitment to governance solutions (eg, better strategy, coordination and planning around climate change mitigation)
Industrial activity growth	Developing world	• Green growth innovations • Low water-intensive industries	• Commitment and collaboration focused on sustainable industrial development
Food security	Developing world	• New genetic strains • Innovative agricultural practices	• Collaboration amongst stakeholders to promote productivity and resilience • Research and development
Insufficient water policies	Global	• Alternative water resource management mechanisms	• Social and environmental impact assessments • Water strategies and resource management • Data collection • Collaboration across government departments
Cross-boundary water systems and resources	Global	• Governance bodies (eg, MRC)	• Regional, national and local collaboration • Collective decision making and regional growth and development strategies • Supranational authoritative bodies with enforcement powers and stakeholder buy-in
Urbanisation	Developing world	• Sustainable consumer products	• Collaboration between public and private sector • Private sector commitment to sustainability

Whilst every effort has been taken to verify the accuracy of this information, neither The Economist Intelligence Unit Ltd. nor the sponsor of this report can accept any responsibility or liability for reliance by any person on this report or any of the information, opinions or conclusions set out in the report.

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