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Irrigation performance benchmarking

Next Generation Water Management Policy Briefs

Cover photo:
Two farmers, both of them landmine victims,
working in a rice field in Cambodia.
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1. Introduction

Reducing rural poverty and improving household nutrition are common goals across all developing countries in the Asia and Pacific region. To this end, the region has experienced a recent resurgence in large investments in irrigation infrastructure. This surge in funding flows has created pressure from donors and central financing agencies, both of which are increasingly demanding more robust justification for the investments. To date, providing this justification for irrigation investments has been challenging due to a lack of reliable longitudinal data that measure the performance of irrigated agriculture and associated water delivery services. Consequently, there is very little information on the real returns on investments already made. Historic data has tended to be project based, point-in-time data constrained to a defined area of infrastructure investment, not on-going and geographically broad-based.

Irrigation benchmarking is a process of comparative analysis of irrigation performance that enables scheme managers to understand the performance of their irrigation services (International Water Management Institute, 2019). To better understand the process of monitoring irrigation performance, this brief will use Cambodia as an illustrative example. Irrigated rice production in Cambodia has significant potential, yet performance of the sector lags behind surrounding countries, such as Viet Nam's delta region (Mainuddin and Kirby, 2009). In addition, there are limited available and published data in Cambodia, making it difficult to analyse the current and changing state of irrigation in the country, the productivity levels, or irrigation's contribution to poverty alleviation and economic growth (Tucker *et al.*, 2020). For these reasons, Cambodia was selected as a country to pilot the transfer of key learnings from the Australian experience of irrigation performance benchmarking, and to develop a benchmarking methodology as a first step to undertake ongoing performance assessment of irrigation schemes for strategic investments in increasing water productivity.

2. Problem definition – the case of Cambodia

Cambodia's economy is largely based on the agriculture sector, and rice production is central to this sector. Rice is predominately grown in the wet season, when approximately 80 percent of the total annual crop is produced. Irrigation is mainly used for dry-season rice and to complete wet-season rice if necessary. Cambodia's irrigation schemes are experiencing several difficulties regarding performance, where ageing or inadequately maintained infrastructure is compounded by deficient institutional arrangements at the scheme and district levels, leading to poor levels of service. This in turn leads to low service-fee collection rates, meaning there are insufficient funds for maintenance and an ongoing cycle of degradation ensues (Wokker *et al.*, 2014). This situation is exacerbated by lack of awareness of water availability and crop requirements by farmers.

Currently, there is significant variability in irrigation development – only 196 out of 946 schemes are fully operational (FAO, 2011). In 2008, the Cambodian Irrigation Scheme Information System (CISIS) was developed as an international collaboration project by the Ministry of Water Resources and Meteorology. The CISIS asset management system was designed to be a dynamic database; however, updating has not occurred continuously, indicators are limited and of questionable quality, and the database is not universally accessible. As a result, knowledge of the condition and performance of Cambodian irrigation schemes is anecdotal, unsystematic, point-in-time, and related to specific projects only.

3. Irrigation performance benchmarking

The overall aim of irrigation benchmarking is to improve the performance of an irrigation farm, scheme or organization. Benchmarking is about comparison – either internally with previous performance and desired future targets, or externally against similar irrigation schemes or organizations (Malano and Burton, 2001).

Benchmarking is about change, moving from one position to a better position. Irrigation and drainage are essentially services to irrigated agriculture that provide and remove water to suit the crops' needs. Therefore, in the irrigation and drainage sector there is a need to improve the level of service provision to water users, thereby enabling them to maintain or increase levels of agricultural production.

The benefit of scheme-level benchmarking is an improvement in level of performance. The performance improvement is visible in the outputs of the organization (such as the level of service provided to water users), and in the organization's internal processes.

Benchmarking the activities and processes of irrigation organizations can provide valuable insight on how well the organization is performing in all areas of service delivery and resource utilization.

Benchmarking can also become an important element of an irrigation organization's accountability. In the wider context of irrigation and drainage, the benefits include improved productivity and efficient use of resources (land, water, labour, finance and agricultural inputs), leading to more productive and sustainable irrigated agriculture and improved livelihoods and well-being of the rural population. In many instances, such improvements, based on the adoption of best management practices to minimize costs and optimize efficiency, will have a positive impact on poverty alleviation.

Features and stages of irrigation benchmarking

For irrigation benchmarking to be successful, broad support across key stakeholders (users, suppliers, regulators and policy-makers) is needed. Therefore, indicators need to be developed that are meaningful, relevant, simple and cost-effective. They should be relatively easy to collect, and receive strong "ownership" support to ensure that diligence is applied when collecting the data, ideally by those who gain to benefit from it. Indicators need to have the same definition and should be measured in the same way across locations and over time to provide robustness and offer opportunities for improvement. Therefore, clear metadata development should accompany the recording of data. This will assist with another requirement that data be auditable; triangulation should assist with validating and cleansing data, but audit trails to the data provenance are equally important.

A benchmarking process usually involves six stages: identification and planning; data collection; analysis; integration; improvement actions; and monitoring and evaluation. Identification should commence with a stocktake and gap analysis of existing data on water resources – for example, infrastructure, technical capacity and gap analysis – and then proceeds to the planning stage, which will require creating a framework for broad endorsement, financial and policy support, and allocation of resources for implementation. Standardization of data may allow for automation of data collection, either in the field (metering) or through remote sensing technology, to reduce human error and build in quality control and assurance procedures.

Source: Tucker, B., Christen, E.W., Quirke, G. & Oemg, C. 2020. *Cambodia Irrigation Performance Benchmarking Framework (CIPBF)*, Technical Report. Australian Water Partnership. Canberra.
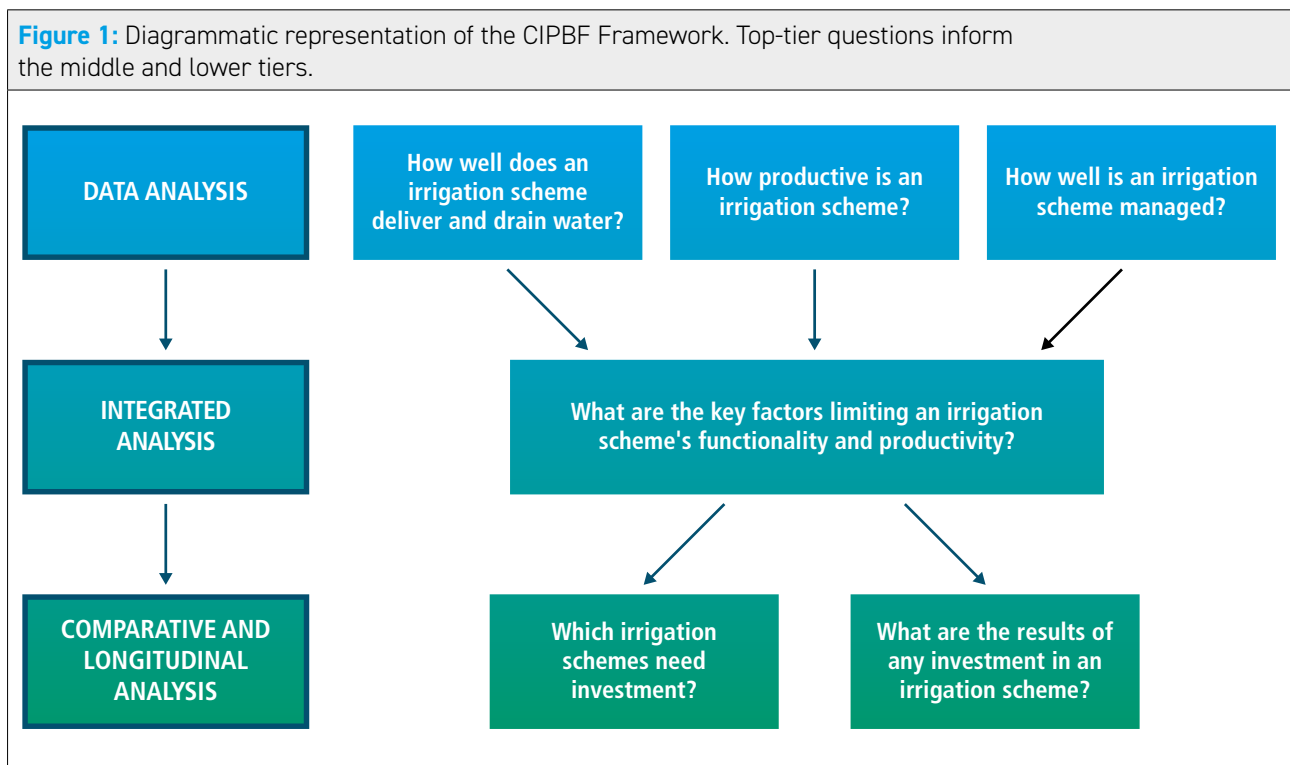
4. The Cambodia Irrigation Performance Benchmarking Framework (CIPBF)

A benchmarking framework was created based on four identified key stakeholder groups.

- Irrigation scheme beneficiaries (farmers)
- The Ministry of Water Resources and Meteorology
- The Ministry of Economics and Finance
- Donors to the Royal Government of Cambodia for irrigation projects (e.g. Asian Development Bank, World Bank).

Of these stakeholder groups, farmers were not part of the project design; instead, they were consulted as part of the process of data-gathering. Key questions were defined at different levels of analysis, as listed in Figure 1 below.

Figure 1: Diagrammatic representation of the CIPBF Framework. Top-tier questions inform the middle and lower tiers.

Source: Tucker, B., Christen, E.W., Quirke, G. & Oemg, C. 2020. *Cambodia Irrigation Performance Benchmarking Framework (CIPBF)*, Technical Report. Australian Water Partnership. Canberra.

The three key questions for the data analysis were used to develop indicators which were simple, affordable, reliable, scalable and locally driven. Information on indicators was collected through a combination top-down bottom-up approach. Top-down, the remote sensing captured production indicators such as cropping intensity, land occupation, crop yield and environmental conditions. Bottom-up indicators, captured through surveys with farmers, included water-level ratios related to consumption and performance and drainage, land occupancy, cropping intensity and yield, and management indicators such as income per unit area, sustainability of irrigable area, infrastructure effectiveness and fee collection ratio.

This pilot project partnered with a team of students and supervisors for field survey collection and collation, and identified technical infrastructure support at government level to carry out the remote sensing elements (Tucker, 2020).

5. Pilot trial

A pilot trial was undertaken by BlackWatch Consulting on four irrigation schemes for which supporting base data were available:[1] Taing Krasaing and O'Kra Nhak (Kampong province); and Prek Chik and O'Tracheak Chik (Battambang province) (Figure 2). The objective was to test the questionnaire and remote sensing methodologies to see if they generated sufficient good-quality data in a cost-effective way for benchmarking purposes.

Figure 2: Location of the pilot trial irrigation schemes. Survey data were collected in three of the four subdistrict schemes in Taing Krasaing, and extrapolated to the other districts. Remote sensing data were collected in the four subdistricts and used to train imagery (remote sensing) for remote sensing data from the other three schemes over a five-year period (2016–2020).
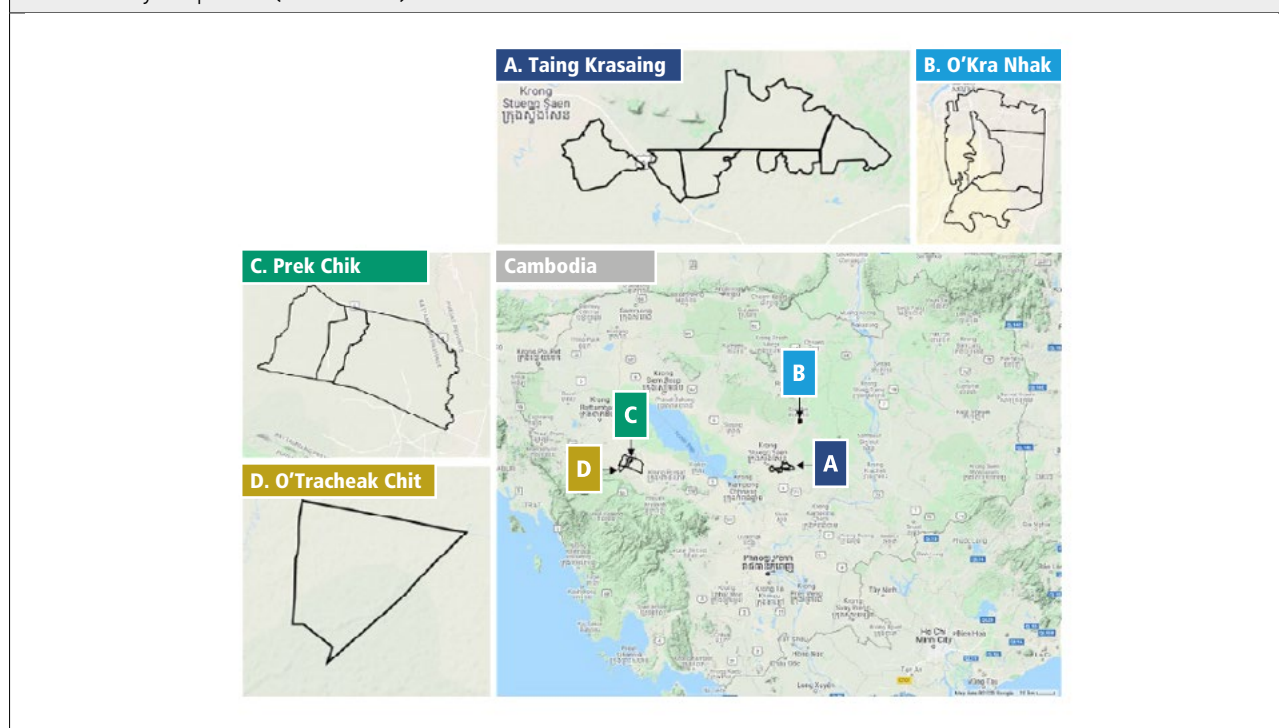
Modified from: Tucker, B., Christen, E.W., Quirke, G. & Oemg, C. 2020. *Cambodia Irrigation Performance Benchmarking Framework (CIPBF)*, Technical Report. Australian Water Partnership. Canberra.

In the Taing Krasaing irrigation district, the three subdistrict schemes TKMC, Chroab and Kokoah yielded 101, 151 and 120 surveys, respectively (372 in total). A list of sub-questions was used to target information on the bottom-up indicators mentioned above. This information is valuable to understand why there are differences in irrigation scheme delivery, productivity and management between the three subdistricts. It complements top-down remote sensing, which can assess spatial changes on drainage, rice production, cropping intensity and utilization of available irrigable area.

In remote sensing, classification of spectral bands is undertaken using field-referenced photographs. This allows for interpretation of imagery of the other irrigation schemes in order to compare trends over a five-year period (2016–2020). Indicators and key summary results from the survey and remote sensing analysis for the Taing Krasaing subdistricts are provided in Table 1. The only remote sensing and survey data that can be directly compared are for *area of crop grown* (cropping intensity and yield), provided that the location of the farm can be accurately determined; this is important for validating the bottom-up and top-down results.

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[1]   Supporting base data included a list of irrigation schemes, their geolocation, shapefiles of outer boundaries, offtakes through main and secondary canals and main drainage points, as well as supporting metadata.

6. Data analysis results

The results of the three key questions (Figure 1) are summarized in Table 1 below.

Table 1: Key questions and indicators, and summary results from survey and remote sensing data analysis for the Taing Krasaing irrigation district (inset Figure 2).

Key questions and indicators	Interview summary results	Remote sensing summary results
How well does an irrigation scheme deliver and drain water? Indicators used (4): • Overall consumed ratio • Delivery performance ratio • Water level ratio • Drainage	• 0–70% of farmers wanted to grow more crops but could not; irrigation system improvement could lead to more cropping. • 5–45% of farmers did not have enough water to finish crops (TKMC being the worst situation). • Only 5% of farmers had to use groundwater. • 15–45% of farmers had to pump water; the canals did not supply their field by gravity.	• Most subprojects' infrastructure functions adequately for draining surface waters. Less than 5% of all subprojects area was covered from November onward. • Kokoah appeared most susceptible to flooding impacts, with 20% of total area submerged in October. This may be the result of an inadequate drainage capacity with the current infrastructure. • Kokoah's drainage issues appear to be concentrated to the downstream, western side of the boundary design area.

How productive is an irrigation scheme?
 	
Indicators used (3):
• Cropping intensity
• Land occupation
• Crop yield
	• The average dry-season rice yield is 2.6 tonnes per hectare.
	• The average wet season rice yield is 1 tonne per hectare.
	• Area of rice in dry season for each subproject was:
	   • Chroab – 80 hectares
	   • Kokoah – 690 hectares
	   • TKMC – 123 hectares
	• Area of rice in wet season for each subproject was:
	   • Chroab – 610 hectares
	   • Kokoah – 980 hectares
	   • TKMC – 540 hectares
	• Combining the above, **total rice produced** by whole of Taing Krasaing Irrigation Project **in the dry season** is estimated at **2320 tonnes.**
	• Combining the above, **total rice produced** by whole of Taing Krasaing Irrigation Project in the **wet season** is estimated at **2130 tonnes.**
		Dry season:
		• The area of rice production is often low, yielding less than 20% for most subprojects.
		• Kokoah had the highest rice production, peaking in 2020.
		• Other crops, such as tree crops (mango, cashew, etc.) may have been classified as "other vegetation".
		Wet season:
		• Rice yields in Chroab, Kokoah and TKMC exceeded 60% of the subproject boundary area.
		• TKMC demonstrated the highest area cultivated of the six subprojects.
		• Tipo 1 – 3 had the least rice area, 30% or less. This may be indicative of other crops classed as "other vegetation."
		• 2016 was significantly drier than other years assessed, indicative of possible drought-like climate conditions.
		• Overall, there was clear evidence that recent investments in the canal network had resulted in increased rice crop area and yields.

How well is an irrigation scheme managed? Indicators used (5): • Income per unit area • Sustainability of irrigatable area • Environmental condition • Infrastructure effectiveness • Fee collection ratio/FWUC function	• Maintenance for Chroab and Kokoah subprojects seems to be adequate but for TKMC subproject it seems to be poor. • Ability to supply water - Overall the scores are only up to 1.5–3.5 out of 5 which is quite low. This indicates that the irrigation scheme is not supplying water up to the farmers' needs. • Issues – the main issues for all subprojects are the canal condition and the condition of structures. Drainage is also an important issue. • Improvement – 55–70% of farmers think that there has been an improvement in the irrigation scheme • Fees paid – the fees paid ranged from USD 4–11, depending on subproject and season.	• Cropping intensity and management are largely low within the Taing Krasaing scheme. Subprojects often have utilisation rates of less than 30% of irrigable command area. • Kokoah displayed a rapid increase in cropping intensity from <5% in 2016 and 2017 to 60–70% of its irrigable command area in 2019 and 2020. • Acceleration in irrigable command area utilisation at Kokoah is likely due to recent investment in system upgrades.

Source: Tucker, B., Christen, E.W., Quirke, G. & Oemg, C. 2020. *Cambodia Irrigation Performance Benchmarking Framework (CIPBF)*, Technical Report. Australian Water Partnership. Canberra.

Table 1 illustrates how well-formulated indicators, based on a framework of carefully structured questions, can yield comparative insights and and help diagnose productivity issues.This in turn can answer key limiting factors and assist in deciding where priority investments would yield optimal return. Extrapolating field-validated results from RS can expand the assessment to neighbouring irrigation schemes (Figure 2), as shown below (See Figure 3).

Figure 3: Comparison of % rice production over several years: dry season and wet season.
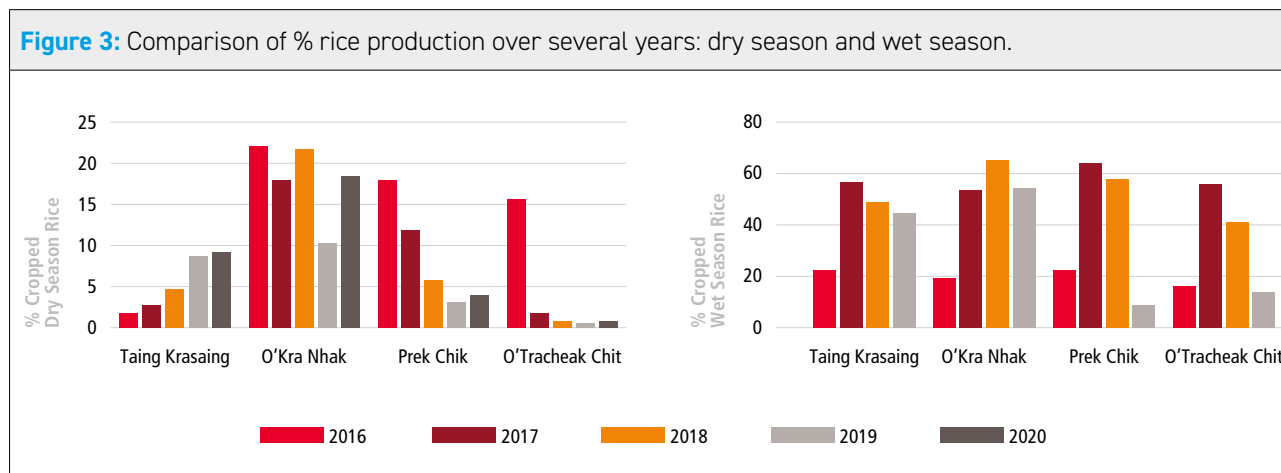
Source: Tucker, B. Cambodia Irrigation Performance Benchmarking Project. 2020. *Cambodia Irrigation Performance Benchmarking Framework Factsheet*. Australian Water Partnership. Canberra.

The data and analysis can be combined to answer three key management questions:

1. What are the key factors limiting an irrigation sche-me's functionality and productivity?

   • The remote sensing and benchmarking questions show that the yields of rice per hectare in both wet and dry season are quite low and the areas of rice grown are not the full cultivable area in the wet season and only a small part of the cultivable area in the dry season. So, both yield per hectare and the small number of hectares grown is affecting the production.

   • The benchmarking questions (Table 1) show that the key factors are the availability of irrigation water in the dry season, which seems to be largely related to the extent of the canal network and its condition. This is demonstrated via farmer responses, claiming that they cannot finish all their crops and that they would grow more crops if services were improved. Many farmers use pumps and some use groundwater showing that the canal system is not supplying adequate water.

   • It appears that the maintenance of the canal system is affecting water supply, suggesting that maintenance could be improved.

2. Which irrigation schemes need investment?

   • The benchmarking questions show that Kokoah has the best production and greatest satisfaction of farmers. Conversely, TKMC has the lowest production and those farmers are not satisfied with the ability of the scheme to supply water or the maintenance of the scheme. Chroab was in between the two. The data can be used to see which schemes are functioning better than others and so potentially where investment in construction and / or maintenance could be best targeted.

3. What are the results (changes brought about) of any investment in an irrigation scheme?

   • Kokoah had recently had significant investment in its infrastructure, and this was shown by the benchmarking results showing higher production and farmer satisfaction than the other subprojects. This type of data collection over time can show the benefits of investment.

Overall, the benchmarking exercise was able to gather useful information about the status across the irrigation projects that would be a useful guide for managers to decide on where investigations are required.

7. Conclusions

The combined field survey and remote sensing approach shows considerable promise as a method for measuring performance and guiding investment prioritisation. The data was able to identify and help account for differences in parameters such as area under production, crop productivity and infrastructure utilisation across the three sub-projects (Tucker, 2020).

With improvements to the planning, design and delivery of the survey, results from the pilot project provide some confidence that a scaled up benchmarking program can provide valuable, affordable and locally driven data on the performance of irrigation schemes, not only in Cambodia but in many countries across the Asia Pacific region.

Additional ground referencing surveys will need to be extended to new agroecological regions and seasons to refine the predictive capacity of the model. While field referencing need not be repeated every year, growing the number of datasets should continue to improve the accuracy of the model.

Before seeking to deploy a benchmarking scheme nation-wide, trials need to be conducted at a large scale. This would include the necessary calibration and refinements of remote sensing, plus greater attention to design and delivery of the questionnaire, using direct data entry and automated data collation and analysis. Conducting an expanded trial in a data-rich irrigation scheme would obviously provide additional benefit in terms of developing a benchmarking framework with indicators that already have demonstrated value in assessing irrigation performance. However, it is recognised that variability in terms of irrigation infrastructure development and data collection is large, not only in Cambodia but in many countries of the region, and initial conditions for benchmarking irrigation performance will remain challenging.

References

FAO. 2011. *AQUASTAT Country profile – Cambodia.* Rome, FAO.

International Water Management Institute(IWMI). 2019. *Online Irrigation Benchmarking Services.* Colombo, Sri Lanka. *https://www.iwmi.cgiar.org/2019/01/online-irrigation-benchmarking-services/*

Mainuddin, M. and Kirby, M. 2009. *Agricultural productivity in the lower Mekong Basin: trends and future prospects for food security. Food Security, 1, 71–82.*

Malano, H. and Burton, M. 2001. *Guidelines for benchmarking performance in the irrigation and drainage sector. International Programme for Technology Research on Irrigation and Drainage Secretariat.* Rome, FAO.

Tucker, B., Christen, E.W., Quirke, G. and Oemg, C. 2020. *Cambodia Irrigation Performance Benchmarking Framework (CI- PBF), Technical Report.* Canberra, Australian Water Partnership

Tucker, B. *Cambodia Irrigation Performance Benchmarking Project. 2020. Cambodia Irrigation Performance Benchmarking Framework Factsheet.* Canberra, Australian Water Partnership.

Wokker, W., Santos, P., and Bansok, R. 2014. *Irrigation water productivity in Cambodian rice systems. Agricultural Economics, 45, 421–430.*

The Next Generation Water Management Policy Brief Collection

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