

Asia Pacific COVID-19 Water Security Risk Index

Prepared for the Australian Water Partnership



Authors

This report has been authored by Lachlan Guthrie (International WaterCentre) and Anne Roiko (Griffith University). The team would like to acknowledge Susan Petterson (Water and Health), Mark Pascoe (International WaterCentre), Marian Neal (The Australian Water Partnership), and Nicholas Schofield (The Australian Water Partnership) for their contribution in reviewing the project.

Acknowledgements

This resource was funded by the Australian Government through the Australian Water Partnership and implemented by the International WaterCentre and the School of Medicine at Griffith University.

The views expressed in this publication are the author's alone and are not necessarily the views of the Australian Government. The Australian Government neither endorses the views in this website, nor vouches for the accuracy or completeness of the information contained within. The Australian Government, its officers, employees and agents, accept no liability for any loss, damage or expense arising out of, or in connection with, any reliance on any omissions or inaccuracies in the material contained in this report.



Summary

The overarching objective of this project has been to create an index that will allow the reader to understand and prioritise what water investments could be made to reduce a country's risk from COVID-19 impacts in the short, medium, and long term.

To do this, the team has created a COVID-19 risk index, building upon the data collected for and the methods used in the Asian Water Development Outlook 2020. We are defining COVID-19 risk as the risk of community wide impact caused by an outbreak of COVID-19, including elements of health, economics, and water security. The index deliberately uses a COVID-19 risk framework that considers all key factors that have a bearing on a country's overall risk from COVID-19, distinguishing those that influence a country's ability to: 1. Stay alert to pandemics in other countries; 2. Prevent/delay 'entry' of the virus across its borders; 3. Contain the community transmission of the virus once it has penetrated its borders; 4. To treat those infected with the virus; 5. To mitigate subsequent substantial outbreaks of COVID-19 via immunity; and 6. To recover from the impacts of a Covid-19 outbreak. It is within this broad contextual framework, that those factors related to water security in various ways are highlighted. This approach allows the most effective water-related interventions to be identified at any given "phase" of the epidemic within a country and recognises that prevention is more cost-effective than treatment.

An analysis of the factors contributing to a country's overall COVID-19 risk index allows the relative importance of those factors related to water security to be identified. In this way, the index is able to highlight those water interventions that are likely to have the most impact on reducing the overall impact of a COVID-19 pandemic. Like any index, its value for prioritising investments is predicated on the availability and accuracy of metrics measuring the factors currently believed to be important for reflecting the impact of a pandemic such as COVID-19 at the country scale. Metrics were not available to some key factors known to be important, such as a country's ability to measure levels of immunity within the community, so these could not be incorporated at this stage. The framework adopted allows these to be incorporated as reliable information becomes available. Assumptions have also been made about the appropriate relationships between component scores making up the index. Given these constraints, any recommendations arising out of the use of the index should not be taken purely on face value and further investigation would be required in the planning phase of each intervention to verify the findings of the index. Geographic variability within countries is also an important consideration when it comes to investing in water security and local knowledge and expertise becomes critical. The key recommendations across the Asia Pacific include.

- Short term priority to improve WASH access, in particular handwashing, in the homes of many Pacific countries
- A medium-term priority to work with water utilities in the Pacific, India, Pakistan, and Afghanistan
- A long-term priority focus on GESI WASH issues in Afghanistan and Pakistan
- Long term focus of improving economic water security in several countries, in particular Afghanistan

Introduction

AWDO

The Asian Water Development Outlook (AWDO) was initiated by the Asian Development Bank (ADB) and the Asia-Pacific Water Forum (APWF) to highlight important water management issues in the Asia-Pacific region. Three editions have been published so far, 2007, 2013 and 2016.

AWDO 2013 was guided by a vision that "societies can enjoy water security when they successfully manage their water resources and services to 1) satisfy household water and sanitation needs in all communities; 2) support productive economies in agriculture and industry; 3) develop vibrant, liveable cities and towns; 4) restore healthy rivers and ecosystems; and, 5) build resilient communities that can adapt to change". AWDO involves five Key Dimensions (KDs) of water security (WS); Rural Household WS (KD1), Economic WS (KD2), Urban WS (KD3), Environmental WS (KD4) and Resilience to Water-related Disasters (KD5).

In both AWDO 2013 and 2016, the importance of continual improvement and innovation was stressed, while balancing the need to enable comparisons through time. The next iteration, AWDO 2020, is in the final stages of development with the IWC leading Rural Household WS (KD1), Urban WS (KD3), and Environmental WS (KD4).

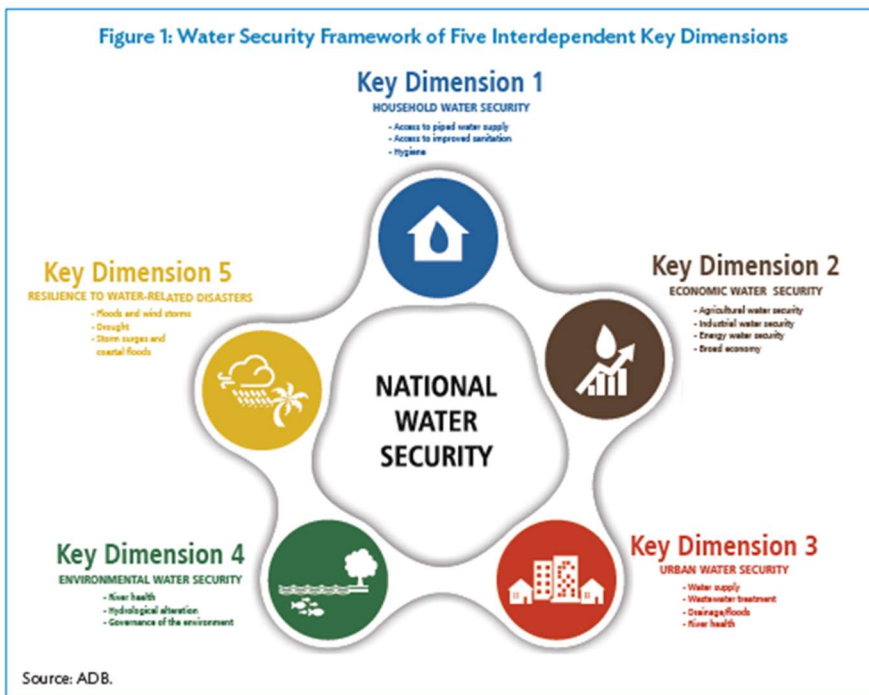


FIGURE 1. KEY DIMENSIONS OF AWDO

COVID-19

COVID-19 is primarily a respiratory illness caused by the novel and highly contagious coronavirus SARS-CoV-2, currently the centre of a global pandemic, with more than 7.4 Million cases reported in 188 countries (as of 13/06/2020). The following combination of features make SARS-CoV-2 very concerning: the transmission of COVID-19 is potent; the infection rate is fast; there is no specific drug or vaccine available and its treatment is mainly symptomatic supportive therapy. It is particularly challenging in developing parts of Asia where high population densities, combined with low infrastructure capacity, make social distancing interventions designed to reduce community transmission, near impossible. These countries typically have inadequate health services, ill-equipped to handle the surges of patients during the peaks of a pandemic. Similarly, in the Pacific, most countries have insufficient health resources to manage this pandemic.

There has been an emphasis on hygiene throughout the COVID-19 pandemic. Along with staying isolated if experiencing symptoms, adequate hand hygiene practices have consistently formed a key part of the advice from health authorities. Access to water is clearly essential for good hygiene practices given that effective handwashing with soap and water for at least 20 seconds is a key primary prevention strategy,

with alcohol-based sanitiser use being recommended if access to soap and water are not available. Another common important intervention to minimise transmission of SAR-COV-2 is social isolation, something that is extremely difficult if there is no access to water and sanitation within premises. Further, it is possible that the COVID-19 pandemic will bring on a world-wide recession even in countries with only minor impacts to their health systems. It is expected that countries that depend on other countries will be most impacted, particularly countries that depend on tourism (like Pacific countries) or countries that depend on imported food. In this case water and water security will play a critical role in a country's ability to recover from the pandemic.

Case studies

To ensure the accuracy of the method and the index, it is important to develop a deep understanding of COVID-19 responses in multiple countries to ensure that relevant factors are included and sufficiently weighted. To do this, it was decided that two rapid case studies would be completed on India and Vietnam. India was selected as it the country with the most cases in Asia (JHU, 2020) as of 9th June 2020. In contrast, Vietnam, was the first country to confirm a positive case of COVID-19 outside of China, to close its borders to visitors from China and has responded well with a total of just 332 cases as of 9th June 2020.

Vietnam

This case study was informed by La, Viet-Phuong, et al. (2020) "Policy Response, Social Media and Science Journalism for the Sustainability of the Public Health System Amid the COVID-19 Outbreak: The Vietnam Lessons." Sustainability 12.7 2931.

Despite being the first country to identify a positive case of COVID-19 outside of China on the 23rd of Jan, Vietnam has been able to contain the spread of the virus and have only recorded 332 cases (as of 9th June 2020). Vietnam acted quickly to try to delay and limit the importation of the virus, as early as the 3rd of Jan Vietnam tightened the border with China and in the ensuing weeks and months tightened and closed borders with China and other countries before most other countries.

Most of the Vietnamese government's actions were designed to contain the spread of COVID-19. The government immediately increased the health system's contact tracing capacity, forced isolation of suspected carriers, pushed strongly to increase their testing capacity, and developed a massive, targeted risk communication campaign. Along with recruiting an "army" of contact tracers, the government published the name, picture, and details of anyone who had tested positive on social media to ensure anyone that had come into contact with them was found. The government also quarantined tens of thousands of people, including entire districts, with all services provided for free by the government. Vietnam also vastly increased their infection testing capacity with Vietnamese researchers developing several diagnostic kits that had even been exported to Europe and the USA. Further, Vietnam used a massive social media push with messaging utilising war metaphors and patriotism and a deliberate focus on science communication to fight misinformation. Recognition of the importance of these early, combined actions was attributed to learning from the SARS pandemic in 2003.

India

This case study was informed by Editorial. (2020). India under COVID-19 lockdown. Lancet (London, England), 395(10233), 1315.

India has had the most cases in Asia to date. Like Vietnam, the government's main actions have been to try to contain the spread of the virus with a large national lockdown, considered the world's largest ever lockdown and drawing praise from the World Health Organisation. However, the lockdown was not successful, with its sudden imposition leaving many vulnerable people including migrant workers with no food. Breaks in the lockdown were needed to allow laid-off workers to either travel home or to work in the

informal economy. The government's attempts to provide food and financial support to those that were vulnerable proved inadequate. While India's relatively young population is a positive factor, the already overburdened medical system is not expected to be able to cope with the influx of COVID-19 patients. Further, there has been significant misinformation driving fear and violence against health workers and the Muslim community.

An interesting feature of the Indian story is that there are significant differences in preparedness and response between states. Notably Kerala, which experienced a Nipah epidemic in 2018, has had significantly fewer cases than most other states.

Approach

The method for this project can be broken down into five components.

1. Creating the framework for assessing the risk
2. Identifying relevant factors and metrics that could inform each component of the risk framework
3. Categorising factors within the structure of the framework
4. Developing an approach for calculating risk element scores (including review of 9 different calculation approaches for a subset of 10 selected countries)
5. Implementation and preliminary prioritisation of 47 countries in the Asia-Pacific region
6. Review of the prioritisation for two specific country case studies (India and Viet Nam)

1. Creating the framework for assessing the risk

To provide a holistic assessment tool, the framework must be appropriate for measuring the risks from COVID-19 to society in general, not only those specific to water. This allows the relative importance of factors reliant on water security during different phases of a pandemic to be assessed. It is important that the framework is based on risk assessment principles of and to include an element of temporality that reflected different phases of the impact of COVID-19 on a country (short, medium and long-term).

In Table 1, previous frameworks considered are listed and how they were included in the final Index outlined.

TABLE 1. ALTERNATIVE FRAMEWORKS CONSIDERED WHEN DEVELOPING THE FRAMEWORK FOR THE COVID-19 RISK INDEX

Framework	Description	How is was included
AWDO KD5 framework (2020)	Framework to measure resilience to water related disasters	Considered but not included
RAND (2016)	Index that measures countries' vulnerability to infectious diseases	Considered but not included
Oppenheim (2019)	Index that measures countries' preparedness for epidemics	Considered but not included
Australian Government H1N1 response (2010)	Phased response plan to a previous pandemic	Appropriated to inform the temporal risk elements of the framework
Madhav (2017)	Pandemic Risk Factors	Elements adopted - This framework considers an important distinction between two components of transmission, the "spark" which considers the illness arriving to the country, and the "spread"

	which considers transmission of the illness in country.
--	---------------------------------------------------------

Consideration of these frameworks resulted in the final framework shown in Figure 2 being adopted. The framework has two sub-indices, likelihood, and consequence of an outbreak. In turn, these sub-indices are comprised of three temporal risk elements appropriated from the Australian Government H1N1 plan.

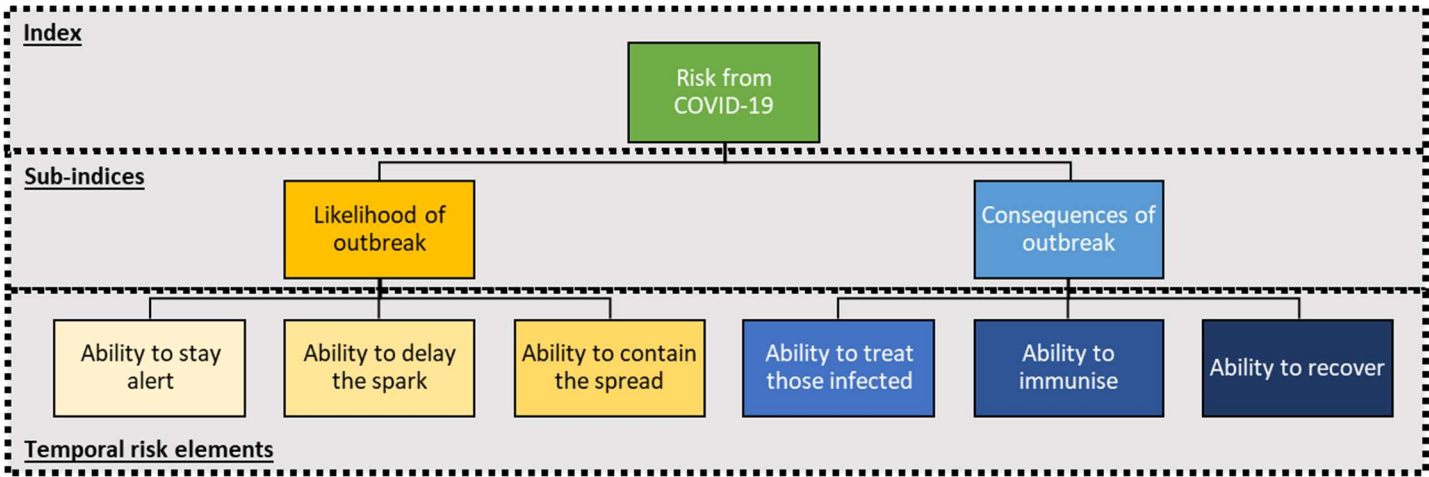


FIGURE 2. PROPOSED FRAMEWORK FOR THE INDEX

Each of the temporal risk elements have been defined in table 2.

TABLE 2. DESCRIPTION OF THE TEMPORAL RISK ELEMENTS

Temporal risk element	Description
Ability to stay alert	A country’s ability to stay alert to potential pandemics in other countries
Ability to delay the spark	A country’s ability to delay a pandemic arriving or “sparking” in the country
Ability to contain the spread	A country’s ability to contain the “spread” of a pandemic and the ability to sustain those containment measures, once it has arrived in country
Ability to treat those infected	A country’s ability to treat those who have been infected. This also includes the prevalence of co-morbidities within the country that influence disease outcomes
Ability to immunise	A country’s ability to control the pandemic through community (herd) immunity
Ability to recover	A country’s ability to recover from the pandemic, including economic recovery

2. Identifying relevant factors and metrics

To identify key factors relevant to assessing the impact of a COVID-19 pandemic, a large truth table was produced to ensure a wide sweep of potential factors was considered. Factors were initially categorised into domains appropriated from the RAND (2016) framework (Demographics, Health Care, Public Health, Economic, Diseases Dynamics, and Political).

The truth table was further informed by the literature to include.

- The relevant sections of AWDO, all five Key Dimensions
- Health related indexes or frameworks
 - Infectious Disease Vulnerability Index (RAND, 2016)

- Epidemic Preparedness Index (Oppenheim, 2019)
- WHO IHR Monitoring & Evaluation (2005)
- Factors that impacted H1N1 mortality (Morales, 2017)
- UNDP Global preparedness and vulnerability dashboards (UNDP, 2020)
- Other related literature
 - Coronavirus disease 2019 (Covid-19) in the EU/EEA and the UK – 9th update (Rapid Risk assessment) (European Centre for Disease prevention and Control, 2020)
 - Actions packages of the Global Health Security Agenda (2013)
 - Indicators of the Morley Utility Resilience Index (2012)

3. Categorising factors within the structure of the framework

After being identified, the factors were re-categorized into the temporal risk elements and a brief rationale was given for including each factor within each category. Potential metrics that could be used to operationalise each factor were then sought. Some factors were associated with multiple metrics, while others had no suitable metrics or data available.

It is important to note that it was through scrutinising the full list of relevant factors, that those with varying degrees of water security relevance could be identified. First, all factors with suitable data available, have been used to assess and rank each country's overall risk from COVID-19 outbreaks. Second, each factor's relative importance is evaluated alongside its temporal relevance in relation to an outbreak. Third, each county's position in the table and the relative importance of water-related factors can be considered alongside other evaluation criteria (such as the capacity to address that factor, cost, acceptability of intervention, and time to influence outcome etc) to prioritise water interventions.

4. Calculating risk element scores

Calculation methodologies from previous frameworks and indices mentioned earlier have been considered in formulating the calculations most appropriate for this index. The calculations and weightings will be confirmed through sensitivity analysis and will follow the principles of:

- Metrics identified for each factor will be normalised from 0-1, with 0 being the “worst possible score”. The values for some metrics needed to be recoded so that the worst case was assigned the minimum score.
- Temporal risk element scores for each of the six temporal risk elements were calculated separately (as shown in Equations 1 and 2 below). It is important to present the risk elements as well as the overall index and sub-indices.
 - Metrics will be categorised into key metrics and non-key metrics. Key metrics were treated differently in the calculations than non-key metrics.
- Sub-index scores will then be calculated for the ‘likelihood’ and ‘consequence’ sub-indices, using weighting factors for the relevant temporal risk element scores (See Equations 3 and 4).
- A similar calculation will be used to calculate the overall risk from the likelihood and consequence. See Equation 5.
- Weighting factors assigned for each metric will be calculated from two components multiplied together to create an overall weighting factor. Each of these sub-weighting factors were based on the subjective assessments of the project team, informed by the literature.
 - Relevance: A measure of how relevant a factor is to the risk component, how close a proxy the metric is for the actual factor identified, and how unique a factor is
 - Quality: An estimate of the quality of the data, also considering the number of data gaps

Refining the method

To refine the method, an iterative approach for improving the calculations and weightings was adopted, following the steps below:

1. Subjective assessments were used to formulate the initial weightings and to decide which metrics were considered “key”
2. The analysis was completed using an original method, shown as method 1A in Table 3 below
3. Based on the results of the first iteration of the analysis, weightings were tweaked to reflect further information sought within the verification countries
4. Multiple methods were assessed for their predicative value within the verification countries

Two key issues with the original method trialled in step 2, were noted:

1. If a country scored poorly in a single **key metric**, it would always receive a very poor score
2. For some metrics, the **normalisation** procedure produced unhelpful results due to the wide range and outlier values for certain countries

The combination of these two issues was most clearly shown in the medical infrastructure factor. As each metric had one or two countries with extreme outliers, 60% of countries received a factor score of 0.1 or lower which resulted in only 44 of the 47 countries being considered very high risk due of their ability to treat. These are not accurate or helpful as they skew the results.

Two other potential revisions were devised for each problem and are shown in Table 3 below. This resulted in a 3 x 3 matrix with a total of nine methods being trialled.

TABLE 3. ATTEMPTED METHODS MATRIX

		Approach to normalisation		
		A: All raw scores normalised from 0-1	B: Raw scores ranked	C: Raw scores normalised with some metrics having upper or lower limits to remove effect of outliers
Approach to key metrics	1: All Key metrics multiplied	1A	1B	1C
	2: Key metrics are multiplied only if more than a single metric is used to represent a given factor. The factor score is then added to other factors through the calculation of a weighted average	2A	2B	2C
	3: Key metrics are treated like non-key metrics (additive), but with extra weighting	3A	3B	3C

Verification

With nine method options being trialled, logic checking was used to determine which was the most appropriate to ensure the results were sound and robust. Ten countries expected to be quite different were

selected to logic check the results. The method that produced results closest to what should be logically expected was selected as the most appropriate method.

The following countries were selected to verify the method.

- Case study countries: India and Vietnam
- Representative countries from South Asia: Nepal (along with India)
- Representative countries from Central West Asia: Kazakhstan and Afghanistan
- Representative countries from the Pacific: Fiji and the Solomon Islands
- Representative countries from South East Asia: Cambodia and Laos (along with Vietnam)
- Representative country from Advanced Economies: Singapore

Following this verification step, method 2B was selected, with countries being ranked for each metric, with key metrics multiplied together before a weighted average is used to find the temporal risk element score.

Further improvements

Following the verification, the following minor improvements were conducted to create the final method.

1. As the passage of the COVID-19 pandemic is well known internationally, all countries received a perfect score for the ability to stay alert. Therefore, as it is no longer relevant to a comparative COVID-19 index, it has not been included in the calculations. However, as it would be relevant in any future pandemic, it is an important inclusion in the knowledge and literature and the ability to stay alert will remain in the framework.
2. The water security related elements for both the ability to contain and the ability to treat were calculated separately as well as together with all the factors to show how much of an impact water had on that temporal risk element.

Final calculation method

In summary the equations used were.

First the weighted average was used to find the risk element raw scores. Each score was between 0 – 1, with 0 being the worst possible score and 1 being the best possible score.

EQUATION 1. CALCULATION OF THE TEMPORAL RISK ELEMENT RAW SCORES

$$\text{Temporal risk element score} = \left(\frac{\sum_{j=1}^y (W_{Factorj} \cdot Factor_j)}{\sum_{j=1}^y (W_{Factorj})} \right)$$

Where:

- $W_{Factorj}$ = Overall weighting factor for risk factor (j)
- $Factor_j$ = Country specific rank of risk factor (j)
- y = the number of factors

A second equation was used to normalise and convert the raw scores into the risk element rating between 1 – 5, with 1 being the lowest risk and 5 being the highest risk. As shown in Equation 2

EQUATION 2. CALCULATION OF THE TEMPORAL RISK ELEMENT RATING

$$\text{Temporal risk element rating} = 1 + \left(4 \times \left(\frac{1 - (TRES_c - TRES_{min})}{TRES_{max} - TRES_{min}} \right) \right)$$

Where:

- $TRES_c$ = Temporal risk element score for country (c)

- $TRES_{max}$ = Maximum temporal risk element score for all countries
- $TRES_{min}$ = Minimum temporal risk element score for all countries

Subsequently likelihood and consequence ratings were calculated from the weighted average of the appropriate temporal risk element ratings as shown in Equation 3 and 4.

EQUATION 3. LIKELIHOOD OF OUTBREAK

$$Likelihood = (Ability\ to\ delay + Ability\ to\ contain) \div 2$$

EQUATION 4. CONSEQUENCE OF OUTBREAK

$$Consequence = (Ability\ to\ treat + Ability\ to\ immunise + Ability\ to\ recover) \div 3$$

Finally, the overall risk from COVID-19 was calculated by multiplying likelihood and consequence, resulting in a rating between 1 – 25 as shown in Equation 5.

EQUATION 5. CALCULATION OF OVERALL RISK FROM COVID-19

$$Risk\ from\ COVID - 19 = Likelihood * Consequence$$

Any gaps in datasets will not be considered by the calculations so as to not bias the results as much as possible.

5. Implementation for all 47 countries

With the calculations finalised the index assessment was completed for all 47 countries. As a final stage to make the data more easily understandable the overall risk rating was converted from a number into a statement in line with Table 4 below.

TABLE 4. RISK RATINGS

Numeric risk rating	Risk rating
15 – 25	Extremely high
12.5 – 15	Very high
10 – 12.5	High
7 – 10	Medium
<7	Low

A summary of the results is shown in Table 5.

Results

Below in Table 5 the results have been shown.

TABLE 5. COVID-19 AND WATER SECURITY RISK INDEX

Country	Overall COVID-19 risk index		Likelihood of outbreak	Consequence of outbreak	Ability to delay the spark	Ability to contain the spread		Ability to treat those in need		Ability to immunise	Ability to recover
						Overall	Water related	Overall	Water related		
Afghanistan	Extremely high	23.3	4.8	4.9	4.7	4.8	4.5	5.0	4.9	5.0	4.7
Micronesia, Federated States of	Extremely high	19.3	4.3	4.5	3.6	4.9	5.0	4.7	4.7	5.0	3.8
Lao People's Democratic Republic	Extremely high	18.8	4.5	4.2	5.0	3.9	3.7	3.7	4.4	5.0	3.9
Nepal	Extremely high	18.3	4.2	4.3	4.8	3.7	3.9	3.9	3.9	5.0	4.0
Pakistan	Extremely high	18.0	4.3	4.2	4.4	4.2	3.7	4.3	4.1	5.0	3.3
Cambodia	Extremely high	17.9	4.1	4.4	4.4	3.8	3.7	3.7	4.6	5.0	4.4
Myanmar	Extremely high	16.7	3.7	4.5	4.2	3.3	3.8	4.4	2.9	5.0	4.0
Timor-Leste	Extremely high	16.7	4.5	3.7	4.5	4.5	4.5	2.3	3.0	5.0	3.8
Papua New Guinea	Extremely high	16.0	3.7	4.3	2.8	4.6	4.9	4.1	3.5	5.0	3.9
Bangladesh	Extremely high	15.3	3.8	4.0	3.7	3.9	4.0	3.6	4.1	5.0	3.5
Tajikistan	Very high	14.7	3.9	3.8	4.0	3.7	2.9	2.2	3.4	5.0	4.2
Solomon Islands	Very high	14.6	3.3	4.4	1.7	5.0	4.6	4.4	3.9	5.0	3.8
Vanuatu	Very high	14.4	3.2	4.5	1.9	4.6	4.8	4.2	4.3	5.0	4.2
Kyrgyz Republic	Very high	13.7	3.7	3.7	4.8	2.6	2.4	2.9	2.4	5.0	3.2
Uzbekistan	Very high	13.6	3.7	3.7	4.3	3.1	3.2	2.7	3.6	5.0	3.4

Bhutan	Very high	13.0	3.1	4.2	4.1	2.1	2.8	3.7	3.2	5.0	3.8
Marshall Islands	Very high	13.0	2.9	4.4	1.7	4.1	3.6	4.3	5.0	5.0	4.0
India	Very high	12.8	3.2	4.0	3.0	3.3	3.5	3.5	4.0	5.0	3.6
Georgia	Very high	12.7	3.3	3.9	4.4	2.2	2.6	4.0	2.2	5.0	2.6
Kiribati	Very high	12.7	3.0	4.3	1.3	4.6	4.7	4.6	4.8	5.0	3.2
Indonesia	High	12.2	3.0	4.1	2.8	3.3	3.5	4.4	3.0	5.0	2.7
Tonga	High	11.2	2.6	4.3	1.8	3.5	3.2	4.3	4.1	5.0	3.4
Tuvalu	High	10.9	2.5	4.4	1.0	3.9	3.9	3.6	3.7	5.0	4.7
Mongolia	High	10.5	3.1	3.4	3.4	2.8	3.7	2.0	3.3	5.0	3.1
Philippines	High	10.5	2.7	3.9	2.6	2.7	2.7	4.1	3.5	5.0	2.6
Viet Nam	High	10.4	2.8	3.7	3.5	2.2	2.3	3.0	2.9	5.0	3.0
Sri Lanka	High	10.3	2.7	3.8	2.8	2.7	2.8	3.3	2.8	5.0	3.1
Fiji	High	10.0	2.6	3.9	1.9	3.2	3.3	4.5	4.0	5.0	2.2
Samoa	Medium	9.6	2.4	4.0	1.9	3.0	3.0	3.9	4.3	5.0	2.9
Azerbaijan	Medium	9.4	2.6	3.6	3.5	1.8	2.2	3.0	3.7	5.0	2.8
Armenia	Medium	9.3	2.7	3.5	3.6	1.8	1.5	2.9	2.5	5.0	2.5
Turkmenistan	Medium	9.2	2.7	3.4	3.2	2.2	1.7	2.8	2.0	5.0	2.4
Maldives	Medium	8.9	3.2	2.8	3.5	3.0	2.2	1.4	2.5	5.0	1.9
Nauru	Medium	8.5	3.0	2.9	1.2	4.7	4.0	2.2	1.6	5.0	1.5
Malaysia	Medium	8.4	2.8	3.0	3.6	1.9	1.6	2.2	1.5	5.0	1.9
Thailand	Medium	8.3	2.4	3.4	3.3	1.5	1.9	3.1	2.9	5.0	2.2
Niue	Medium	8.1	2.1	3.9	2.0	2.1	2.5	1.7	2.1	5.0	5.0
Cook Islands	Medium	8.1	2.0	4.0	1.0	3.0	2.7	3.1	2.9	5.0	3.9
Palau	Medium	7.9	2.4	3.3	2.7	2.0	1.4	2.4	1.8	5.0	2.5
Kazakhstan	Low	6.8	2.2	3.1	3.3	1.1	1.7	2.5	2.1	5.0	1.8
Brunei Darussalam	Low	6.7	2.5	2.6	3.6	1.5	1.5	1.7	1.3	5.0	1.2
China	Low	5.8	1.8	3.2	2.3	1.4	2.4	2.6	3.3	5.0	1.9
Japan	Low	3.8	1.5	2.5	1.3	1.8	2.1	1.0	1.1	5.0	1.4

Korea, Republic of	Low	3.8	1.6	2.4	2.1	1.1	1.4	1.1	1.2	5.0	1.0
New Zealand	Low	3.3	1.3	2.5	1.5	1.0	1.0	1.5	1.1	5.0	1.2
Singapore	Low	3.3	1.2	2.6	1.5	1.0	1.1	1.5	1.0	5.0	1.4
Australia	Low	3.2	1.3	2.4	1.5	1.2	1.6	1.3	1.2	5.0	1.0

Case studies

As mentioned in the introduction, case studies were developed of both India and Viet Nam to validate the findings of the index. The results from the index for Viet Nam showed that while it was strong in its ability to contain the spread, it was relatively weak in its ability to delay the 'spark' and average for its ability to treat and recover. This is consistent with what was learned from the Vietnamese case study and experience to date. Further, the results from the index for India showed that while it is least vulnerable in its ability to delay the spark (relative to other risk elements), it is vulnerable in all other risk elements. This is consistent with what was learned through the case study as India began seeing significant cases later than many other countries, but when it arrived, it had devastating impacts and quickly became uncontrollable. As the index has in both cases produced results that are predictable from the literature, we see that the index is somewhat validated.

Discussion and conclusion

This project has created and validated a rapid COVID-19 and water security risk assessment method and indexed 47 countries in the Asia Pacific. The project developed a risk based holistic pandemic framework from which factors relevant to the impact the COVID-19 may have in a country were categorised. This framework and factors lead the development of a method for calculating each country's overall risk and a rating for five temporal risk elements. As water services can greatly improve a country's response to this pandemic, many of the factors are related to water security. By understanding how these water related factors impact a country's risk from COVID-19, potential water security interventions that address relevant factors can be identified, screened, and prioritised prior to a more detailed planning phase. Further, the nature of the method used to create the index allows for it to become a "live" tool, possible to update regularly with new factors, datasets, or weightings as new science or data becomes available.

The major limitation of the assessment tool is that better datasets are needed in order to fully understand each country's risk from COVID-19. Of note, there are major data gaps in the Joint Monitoring Program Handwashing and WASH in public spaces datasets and the IBNet Water Utility database does not include many of the critical elements when determining a water utility's vulnerability and has limited recent data. Further, some critical non-water related datasets were also not able to be found, in particular the time since a major pandemic and an appropriate metric that reflects high density populations and their ability to isolate.

Pacific countries (and Timor-Leste) have a high ability to delay the spark of the pandemic (due to tight control of their island-borders) but were the pandemic to take hold they have little ability to contain the virus or treat affected patients. In much of the Pacific, access to WASH in the home is a key contributor to these vulnerabilities. Further, due to their high dependence on tourism it may be difficult for governments to keep borders closed for extended periods of time, making them vulnerable to more "sparks" in future. Further, many water utilities in the Pacific have a low income to expense ratio. This means that they are supported by subsidies which could be reduced because of COVID-19 impacts internationally, particularly if government income from tourism is significantly reduced, this could place the utilities at risk of not being able to pay expenses and becoming unviable.

In Central West Asia, Pakistan and Afghanistan are two of the most at risk countries in the Asia-Pacific. Both are at risk because of many factors including those related to water. Improving WASH in the home would significantly help both countries to contain the spread of the virus, though it may be too late to act on this for the current wave of this pandemic as they are both already seeing significant case numbers. Both countries have high levels of water collection burden, which predominantly falls to women, therefore there may be further gender equality related WASH issues caused by the pandemic. Water utilities in both countries have low income to expense ratios meaning their utilities are vulnerable, particularly in

Afghanistan, due also to high levels of foreign aid dependence. Afghanistan has a further issue in that their economic water security is poor, which may impede its ability to recover from the impacts of COVID-19.

In South Asia there is a clear differentiation between the continental and island nations. Continental South Asia countries have similar risks to Pakistan with Island nations being relatively low risk overall.

The South East Asian region has a relatively strong ability to contain the spread, which is in line with the number of cases that have occurred in many of these countries. However, South East Asia generally has a low ability to delay the spark and therefore is at higher risk of subsequent, multiple waves of the virus. Were a wave to spark and spread uncontrollably, most countries in the region will have difficulty treating patients. As such, continued border shutdowns and vigilance are crucial.

Limitations

The primary limitation of this study and resultant index is that COVID-19 is a new illness and relatively little is known about it or the SARS-CoV-2 virus that is responsible. While the assessment has been completed with reference to the best available scientific information as of early June 2020, this will become outdated quickly. It is likely that new factors will need to be added, data may become available for factors identified but not included to date due to a lack of data, and calculation methods may need to be altered. For this reason, it is proposed that this index become a living document, revised monthly to ensure it stays up to date with the latest science.

A further key limitation, which is a limitation of all indexing methods, is that there is a lack of available, appropriate data available to represent all the factors identified as being important. This means that factors often need to be represented by proxy metrics that are not entirely appropriate or that certain factors are not able to be included at all. Further to this point, some key datasets (in particular access to handwashing and WASH in public places) had many data gaps. Access to handwashing, in particular, is so vital for a country's ability to contain the spread of the pandemic and therefore any index will become more difficult to accurately assess the risk from COVID-19 if many higher risk countries do not report on it.

Another limitation is in the overall risk rating given to each country. While the equation to calculate it is relatively robust, it is inevitably an oversimplification, not able to capture the whole, complex story. For example, while appearing to be relatively high risk, Pacific countries have generally recorded a low number of cases. This is the result of these countries closing their borders (reflected by high scores for "ability to delay"). However, were the virus to arrive in significant numbers in a Pacific country, it would likely be very difficult for the government to contain or treat the illness and it would have devastating impacts. For this reason, it is recommended that the overall risk rating be used mainly as an initial guide, with the temporal risk elements providing a much more useful profile of risk. In addition, all the findings of this index will need to be ground-truthed during the planning of any project. As such this work would benefit from an extension project in which each country's COVID-19 story was told, similar to the India and Viet Nam case studies, and reflected upon in light of the results from the index to support discussions around DFAT supporting COVID-19 responses. This extension should also comment on the impact of data gaps on each country and create priorities for country specific water-based interventions.

Key recommendations

Several key recommendations have been developed through this project. As mentioned in the limitations this tool can only prioritise and shortlist potential interventions and further targeted investigation is required to confirm the findings in the planning phase of any future intervention. The recommendations below target the specific risks discussed above and have been categorised into short, medium, and long term.

Short term recommendations include:

- Urgent focus needs to be placed on increasing WASH in the home, in particular access to handwashing in many Pacific countries. This would increase these countries' ability to contain the spread of COVID-19 if it arrives when borders are reopened to tourists.
- WASH in the home also has a large impact on COVID-19 risks in continental South Asia, Pakistan, and Afghanistan, however as there are already many cases in these countries it may be too late for this response.

Medium term recommendations include:

- As a priority action, funders should immediately focus on improving international water related datasets.
- Interventions should work with water utilities in particular in India, Pakistan, Afghanistan, and throughout the Pacific to ensure they remain viable if government subsidies are reduced due to the crisis.

Longer term recommendations include:

- Interventions should work with authorities in countries with poor economic water security to increase the water sectors ability to aid recovery. The index indicates that Afghanistan and India are the two highest priority countries.