Understanding water modelling capacity and use in Asia and the Pacific

Next Generation Water Management Policy Briefs
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Next Generation Water Management

Brief 4: Understanding water modelling capacity and use in Asia and the Pacific

1. Introduction

Water modelling provides powerful capabilities in collecting, using and extrapolating hydrologic data for a wide range of management and planning purposes, risk reduction, adaptation and integrated water resources management. Analysis of the extent of water modelling capacities in the Asia-Pacific region is essential to effectively target activities and investments that support countries in improving their water management policy and practice.

In this context, the United Nations Food and Agriculture Organization (FAO), in partnership with the Stockholm Environment Institute, carried out detailed capacity assessments in seven countries in the Asia-Pacific region based on highest score for climate related disasters in 2019 (Bündnis Enwicklungshilft, 2020): Bangladesh, Fiji, Indonesia, Myanmar, Nepal, Thailand and Viet Nam. The main objective of the assessments was to better understand water modelling capacities, and the extent to which modelling is used in policy development and implementation.

The assessments consisted of a literature review, baseline assessment, regional survey and validation workshops. This brief summarizes key findings related to current capacity levels, gaps in water resources modelling, and the barriers that are preventing water modelling from influencing policy- and decision-making in practice.

First, a summary of key challenges is presented for each of the seven countries. Next, modelling capacity and applications are discussed, and the use of water resource modelling on policy and decision-making is presented. Gaps and barriers in model development, and how this influences policy and decision-making, are then identified. Finally, the next steps for improving water modelling for the Water Scarcity Programme are presented.

2. Water challenges in the Asia-Pacific region

Countries in the Asia-Pacific region face a vast array of water management challenges, many of which are shared, and many others that are unique to the specific national context. This section summarizes the diversity of challenges to help inform the analysis of modelling capacity and the extent to which modelling capacities link with the policies that have been designed to tackle these challenges.

**Bangladesh** is characterized by a low-lying delta area, with sea-level rise and cyclonic storm surges constituting major threats to water security. Large parts of the population have no access to safe potable water, which is mainly accessed from groundwater sources that are being depleted and contaminated by untreated wastewater, salinity intrusion, arsenic content in soils, and reduced protective coastal vegetation cover (Ahmed, 2021).

The island state of **Fiji** in the Pacific is also vulnerable to rising sea levels, floods, tidal surges and salinity intrusion (Government of the Republic of Fiji, 2018). Fiji faces water quality challenges related to contaminated surface and groundwater. Agricultural demand is modest compared to other uses, and groundwater use for agriculture faces competition from other major uses, particularly domestic.

**Indonesia** suffers from its uneven distribution of water across its large archipelago, with severe water stress in heavily populated areas such as Java and Sulawesi and increased frequency of flooding in low-lying areas, worsened by a changing climate. Indonesia’s rivers and groundwater are heavily contaminated by massive pollution due to a combination of untreated domestic sewage, solid waste disposal and industrial effluents, leading to both human and ecosystem health problems (ADB, 2016; Danielaini et al., 2019).

**Myanmar**’s water resources, stemming from four large river basins and two coastal river basins, remain underutilized, with irrigation coverage accounting for only 16 percent of the total land usage and for low crop productivity; most agriculture is rainfall-based (MoNREC, 2020). More than half of the population resides in the lowlands (in particular the Ayeyarwady Basin), where intensity and frequency of floods have increased. Water scarcity is most prominent in the Central Dry Zone.

In **Nepal**, a landlocked and resource-rich country, rainwater-fed agriculture is the main source of income...
for 66 percent of the population. Challenges include deglaciation (Jones, et al., 2018), inferior infrastructure and unplanned urbanization. (ADB, 2020). The country is highly vulnerable to climate change, and a third of the population experiences seasonal water scarcity.

Despite having high per capita water resources, **Thailand** experiences seasonal water scarcity, in addition to recurrent droughts and floods. The absence of an enforceable water allocation system is leading to increasing conflict, which is exacerbated by saltwater intrusion, declining water quality in production wells, forest loss and ecosystem degradation. Future trends predict that by 2038 demand will exceed supply, mostly affecting populations in the central plain and north-east Thailand (Chaowiwat et al., 2019).

**Viet Nam** is a water-rich country, but 60 percent of its water originates from outside its borders, thus making the country vulnerable to upstream decision-making (World Bank Group, 2019). Serious pollution occurs in surface and groundwater sources, contributing to water scarcity and environmental degradation. In addition, limited surface water has depleted groundwater levels in the lower delta, causing salinity intrusion and affecting agricultural (rice) production.

### 3. Capacities in water modelling

Based on an online survey of 24 government agencies in seven countries, national modelling skills are well developed in Bangladesh, Indonesia, Thailand, and Viet Nam, but tend to focus on routine hydrology and project-based applications. Bangladesh is the only country that has a focus on groundwater modelling. However, groundwater data are scarce. Bangladesh requires data support on pumping rates, yields, water tables, aquifer characteristics and boundaries, as well as information on salinity, bathymetry and sediment fluxes. Fiji needs better elevation data, groundwater salinity at different depths, groundwater depth to monitor volume changes, time series flows and groundwater and topographic data at high spatial resolution. Indonesia needs the projected demands in sectoral water use at fine spatial resolution and improved water quality data. Myanmar lacks reliable estimates of rainfall, evapotranspiration and land use/cover through high-resolution georeferenced satellite data. Nepal did not indicate the need for supplementary data for water resources modelling.

Thailand has a need for high-resolution digital elevation model, discharge, land use/cover, groundwater, water quality, environmental flows and meteorological data at local level. In Viet Nam, a major issue is a lack of soil moisture and available water capacity data at field scale, and topographic data for the assessment of urban flood risks at city scale.

In the selected countries, model development and application are primarily undertaken for hydrological forecasts (17 percent) and early warning and assessment (15 percent), followed by water resources planning and management (14 percent), research and development (14 percent) and impacts of climate change, often with international assistance (12 percent). Climate change modelling is typically coarse-scaled and reliant on global data sets, casting doubt on its usefulness for water availability beyond general predictions, given the complex climates and inefficient calibration against historical rainfall records. In many countries, multiple agencies undertake modelling and there is a degree of overlap in data collection and modelling.

The main focus of modelling is on routine hydrology and project-based applications, with the types of models being statistical (45 percent), lumped (30 percent), fully distributed (15 percent) and semi-distributed (10 percent). Problems with the models in use include a lack of sufficient spatial and temporal data to support fully and semi-distributed modelling (producing misleading results) and the manual collection of field data (silhoed, incomplete, prone to transcription errors).

Open source (38 percent), freeware (27 percent) and licenced software (27 percent) are used most frequently, compared with internally built software (8 percent), suggesting that limited capacity exists for developing purpose-built models.

Water accounting to assess and test scenarios of water allocation is occurring in all countries at different scales but is far from comprehensive, with 42 percent of staff indicating that water accounting models are currently being developed. Eleven percent of agency staff are not aware of water accounting being used for allocation, and 47 percent indicated that it does not occur in their department. As a result, water modelling to underpin water allocation remains in its infancy in most cases; where it does exist, it is project-based rather than systematic.
4. Use of water resources modelling in policy- and decision-making

Overall, water resources modelling is mostly used in policy formulation when different options or strategies need to be considered about designing programmes, and decisions made on investment and resource commitments (Figure 2). Bangladesh, Indonesia, and Fiji appear to make the greatest use of modelling for policy development, with Bangladesh using model results across a wide range of policy elements, including agricultural and urban water management, dams and hydropower, disaster risk reduction, irrigation expansion and integrated water resources management, and Sustainable Development Goal (SDG) targets. Other elements of policy formulation used by some countries include environmental flows, sediment management, navigation, tourism, water quality, biodiversity, domestic water management and climate change adaptation.

Modelling for policy implementation is mainly occurring in Thailand for agriculture, irrigation expansion and disaster risk reduction, and in Bangladesh for integrated water resources management and SDGs. Agenda-setting is informed by modelling only in Fiji regarding awareness-raising for agriculture management and impacts from climate change, whereas ‘other’ constitutes Myanmar for purposes of sediment management, navigation and tourism.
Figure 2: Use of models in policy- and decision-making.

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy implementation: policy administration activity on the ground</td>
<td>25%</td>
</tr>
<tr>
<td>Agenda setting: raising awareness of problem or issue</td>
<td>12%</td>
</tr>
<tr>
<td>Policy formulation: providing analytical options in strategies</td>
<td>50%</td>
</tr>
<tr>
<td>Other</td>
<td>13%</td>
</tr>
</tbody>
</table>


5. Gaps and barriers

Many national agencies in the Asia-Pacific region still face difficulties in accessing field observation data and modern hydrological information systems. Hydrological observation networks remain sparse in the selected countries, except in Thailand and Viet Nam, and do not support national needs. Data management systems are often lacking, going hand in hand with insufficient spatial and temporal data to support modelling. In addition, scant data quality checking of records means only half of the countries prepare and store data according to international standards. Field data still tend to be stored on paper or propriety databases within the relevant agency, resulting in transcription errors, duplication, and lack of transparency, transferability and data sharing.

Model development remains in its infancy stages in all countries due to: (i) lack of technical and research management skills to improve use and application of remote sensing and hydrological modelling and applications; (ii) infrequent updating of model software; and (iii) insufficient skills in building a model and interpreting results. Limited funding and support for observation networks and deteriorating existing networks contribute to this situation. Consequently, model outputs are frequently used at departmental level, but are not effectively informing decision-making and high-level policy development, despite survey results suggesting that they are considered important in different processes, such as agenda-setting, policy formulation, policy implementation, and monitoring and evaluation.

6. Recommendations – Next steps

It is clear from this analysis that much remains to be done to enhance modelling and its effectiveness in improving the design and implementation of the policies needed to effectively tackle the challenges that each country is facing. The next steps in addressing gaps and barriers are described in the paragraphs that follow.

Integration

- **Scaling up models.** The design of water accounting models needs to be scaled up in existing or new projects.
- **Integrating data.** The integration of databases, the selection of models to match available data, and the development of well-conceived scenarios to explore viable policy options would significantly improve water modelling capacity. A good example exists in Thailand, which has established a central database centre being operated by the Hydro-Informatics Institute (Council Ministers of Thailand, 2019; Hydro-informatics Institute, 2019). Although requiring further work to integrate data at subnational level, this initiative could provide a template for other countries in the region for unrestricted data-sharing and information exchange. Such
a template should include data on surface and groundwater, so that coupled models can be developed for comprehensive scarcity assessment.

- **Improving coordination.** Coordination of water-related activities carried out by multiple agencies within each of the countries needs to be improved and form the basis for transboundary collaboration.

### Engagement

- **Formulating long-term planning for capacity-building.** Long-term planning for capacity-building at national and subnational levels would create buy-in, support and political will to progress water scarcity management. The planning should involve the assistance of academic institutes and NGOs, linked with investment plans using a co-design, co-development and co-implement approach to build ownership and partnership.

- **Creating innovative platforms.** Creating innovative platforms, such as policy dialogues, would enhance and increase interaction and communication between technical groups and policymakers to exchange and share information, using interpretation and visualization techniques.

- **Minimizing duplication in investment.** Development partners should assist countries to reduce duplication in investment. This requires analysing past investment data in water modeling and setting an agenda for improved policy coherence, aiming to improve financial mechanisms for greater effectiveness and efficiency.

### Institutional reform

- **Establishing a central body.** Each country should set up a central body to ensure unrestricted data-sharing and information exchange between subdepartments in any institution, and between government agencies, according to affordable and practical standards; this should allow different agencies to be centrally coordinated. Data and model standards should ensure quality control and be established based on international standards, where applicable, to enable sharing information internally as well as in a transboundary context.

- **Testing new ways of collaborating.** Institutional reform is a long-term objective, which complements long-term planning and can be initiated by creating innovative platforms that provide the space to test new ways of collaborating before they become institutionalized for long-term trajectories.

In conclusion, modelling capacity in the Asia-Pacific region is currently undertaken on an agency basis within each country. Existing models often have a narrow scope or objective regardless of their spatial application or are project-based and with limited general applicability. Capacity-building remains fragmented across multiple agencies and needs to be better integrated in order to enable integrated water resources management. Given the challenges of increased demand resulting from population pressure, and climate change impacts that may reduce supply and increase uncertainty, better coordination would lay the groundwork for integration, engagement and long-term institutional reform. This will require a regionally coordinated effort, in which international support via aid, and global and regional data and expertise will have a significant role to play.
References


The Next Generation Water Management Policy Brief Collection

This Briefing Collection has been developed to inform policymakers of new and improved approaches to different aspects of water resources management for agriculture and food security across Asia and the Pacific. Each brief promotes cutting-edge approaches in water management that are being developed and implemented by FAO and its key technical partners. Content for this Briefing Series draws from two major programmes led by FAO’s Regional Office for Asia and the Pacific:

**Asia Pacific Water Scarcity Programme (WSP):** The WSP aims to bring agricultural water use to within sustainable limits and prepare the agriculture sector for a productive future with less water. The WSP is assessing the scope of water scarcity in the region, evaluating effective management response options (primarily water accounting and allocation), supporting improvements in governance, and assisting partner countries to implement adaptive water management in the agriculture sector using appropriate and newly developed tools and methodologies. The WSP is also establishing a regional cooperative platform to enable countries to share solutions and experiences, in addition to ensuring national engagement at the highest political level.

**Next-Generation Irrigation and Water Management Programme (NextGen):** NextGen draws on global best practices to accelerate the modernization of irrigation systems and water management practices in Asia and the Pacific. NextGen aims to ensure a bioeconomy that balances economic value and social welfare with environmental sustainability. The programme addresses cross-cutting issues in irrigation and water management, such as irrigation performance, food security, eco-system health, gender equality, fisheries, and aquatic biodiversity. In this way, NextGen promotes the implementation of integrated and evidence-based policies and practices in micro and macro environments, using technological, organizational and social innovations. NextGen is undertaken in collaboration with the Australian Water Partnership, supported by the Australian Department of Foreign and Trade (DFAT).