# Fact Sheet on PUB's Thematic Request for Proposal (RFP) 21/02 on Projecting the Impacts of Climate Change on Singapore's Water System

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## Background

The Competitive Funding for Water Research (CWR) is a competitive funding scheme under the Urban Solutions & Sustainability (USS) domain. The aim of the CWR is to fund basic / applied R&D projects, which possess recognisable potential for developing into innovative solutions for the water industry.

## Present call

1. Singapore is a water stressed country. While it has built up a diversified water supply through its Four National Taps, Singapore's water demand is projected to increase and double by the year 2060. Amidst the projected increase, coupled with climate change and other uncertainties in the global context, it is critical to ensure that Singapore's water supply remains resilient and sustainable to continue supporting the nation's growth.

2. As the effects of climate change become increasingly pronounced around the world, PUB needs to position itself to address the longer-term impacts of climate change on Singapore's water systems, including the effects on various water sources (e.g. local catchment, seawater and NEWater). This Thematic RFP hence solicits proposals to study the impact climate change has on the Singapore water system for the next 10, 20 and 40 years, so as to guide the formulation of future adaptation strategies.

3. The proposal shall address two focus areas, namely the impact to (i) water quality and (ii) PUB's infrastructure. To guide proposal conceptualisation, the Applicant shall address (some of) the key topics and questions listed in Appendix A. The Applicant is also free to propose other areas of study, *except for areas related to flooding and coastal protection* where separate studies are already ongoing.

4. Each proposal should include the following:

    a) Identify the possible impacts climate change can have on PUB's water systems[1];
    b) Assess the probability and extent of the potential impacts;
    c) Recommend adaptation strategies to address the adverse impacts identified; and
    d) Carry out techno-economic analyses on the proposed adaptation strategies.

5. The proposed methodology in carrying out the impact study should be clearly stated in the proposal. The Applicant can consider a mix of approaches including literature review, modelling and simulation, small-scale and short-term lab/field studies (mainly for the purpose of collecting baseline information), consultations with subject matter experts, etc.

6. The Applicant shall propose an assessment methodology and apply it to the proposed adaptation strategies. In recommending the adaptation strategies and solutions, the Applicant should consider cost-benefit analysis (weighing the probability and extent of climate change impacts, cost of implementing solutions, etc). The methodology shall include appropriate assessment criteria or a scoring framework, so the proposed

[1] The international water basin between Singapore and Malaysia shall not be included under this study

strategies can be evaluated and compared against one other. The evaluation shall be presented clearly in the proposal in a suitable format (e.g. as an evaluation matrix).

7. The proposal shall consider the climate change impacts with respect to the entire water loop[2]. The proposal can thus comprise different work packages with each investigating the impacts on specific segments of the water loop. The proposal shall be led by a main Principal Investigator (PI), who will coordinate and integrate the work of other relevant parties from the different work packages.

8. The proposal shall build on the findings from the 2nd National Climate Change Study (V2)[3] for Singapore and past PUB studies (more info provided below and in Appendix B). Based on the 2nd National Climate Change Study which analysed Singapore's climate up to the year 2100, it is projected that Singapore is likely to become warmer, experience more frequent and heavier storms, and face rising sea levels. The key findings from the study include:

    a. Temperature
    Daily mean temperatures are projected to increase by 1.4 to 4.6 degree Celsius towards the end of this century (2070 to 2099), compared with the baseline period of 1980 to 2009.

    b. Rainfall
    The contrast between the wet months (Nov to Jan) and dry months (Feb and Jun to Sep) will likely become more pronounced. Increasing trends in both intensity and frequency of heavy rainfall events are expected as the world gets warmer.

    c. Sea level
    Mean sea levels are projected to rise by up to about 1m by 2100, compared with the baseline period of 1980 to 2009.

    d. Frequency of warm days and nights
    More warm days and warm nights for Feb to Sep are projected throughout the 21st century.

    e. Wind
    Singapore will continue to be influenced by the northeast and southwest monsoons with potential increase in wind speeds during northeast monsoon season.

    More information and findings from previous studies are provided in Appendix B. Applicants may refer to the V2 Stakeholder's Report (available online)[4] which will form the basis of climate change trending for the submitted proposals. Applicants are to note that the proposed study shall be updated with the latest information from the 3rd National Climate Change Study when the findings are published (V3; tentatively in 2022/ 2023).

[2] The study shall exclude areas related to flooding and coastal protection as separate studies are already ongoing.
[3] Information extracted from "Singapore's Climate Action Plan: A Climate-Resilient Singapore, For a Sustainable Future" (2016), available at www.nccs.gov.sg/docs/default-source/publications/a-climate-resilient-singapore-for-a-sustainable-future.pdf
[4] Available at http://ccrs.weather.gov.sg/Publications-Second-National-Climate-Change-Study-Science-Reports

9. All research activities have to be carried out in Singapore. Cross-disciplinary and multi-disciplinary research proposals are strongly encouraged, as well as proposals from research consortia involving partners drawn from different private and public organisations and academic institutions, including international collaborations with renowned experts to introduce new research capabilities and transfer of technical expertise to Singapore.

10. R&D proposals already funded by other agencies or being considered for funding by other agencies will not be considered under the present call. Applicants will need to declare other funding sources in the application.

## Eligibility Information

11. This call is open to Institutes of Higher Learning (IHLs), public sector entities and private sector companies based locally in Singapore. Under this Thematic RFP, IHLs and public sector entities will qualify for 100% funding support of approved qualifying costs and 30% overheads. Funding support for non-Singapore entities is up to 30%, Large Local Enterprises up to 50%, Singapore Small Medium Enterprises, start-ups and not-for-profits up to 70%.

## Application Procedure

12. To apply, the Applicant must submit the proposal using the 'CWR Research Proposal Form', which can be downloaded from the online Integrated Grant Management System (IGMS)[5]. Please refer to **Annex A** for detailed guidelines for the submission of the proposal and **Annex B** for guidance on creation of account in IGMS.

13. The proposal shall include, but not limited to:

    i. Scope – clear description of the scope of the study

    ii. Approach and methodology – full technical details on the approach and methodology of the proposal to deliver the expected outcome as mentioned in Para 4

    iii. Project Team - The proposed team members' expertise, previous related work and experience (2-page CVs shall be submitted for the Lead Principal Investigator, as well as for all co-PIs and collaborators).

    iv. Budget - Detailed budget required for the project (broken down into individual categories of manpower, equipment, consumables, travel, consultancy services, others).

    v. Timeline - Timeline for the project, showing intermediate milestones to be achieved.

[5] https://researchgrant.gov.sg

vi. Deliverables - Expected research outputs and outcomes and proposed key performance indicators (KPIs) for the project.

vii. Intellectual Property (IP) - highlight how the IP created will be owned and commercialised, and how the benefits from these commercialisation plans can be accrued to Singapore.

14. The deadline for the Proposal submission is on **26 November 2021, 4:00 pm** (Singapore time, GMT +08:00).

## Evaluation Criteria

15. Proposals received shall be sent to international peer reviewers for technical/scientific merit review. If appropriate, proposals from academia may also be sent to Industry Resource Persons (for commercial viability) and relevant national agencies (for national relevancy) for review. This is then followed by evaluation by CWR's Project Evaluation Panel (PEP), which comprises local and international experts as members. The PEP shall evaluate the proposal based on the criteria given in Para 16, referencing reviews from international peer reviewers, and make a recommendation whether to fund it.

16. All Proposals are evaluated against the following criteria:

i. Excellent science and cutting-edge technology, with proposed activity involving innovative and cutting-edge research that seeks to bring together the best R&D talent available.

ii. Significant economic or social benefits, to be accrued to Singapore through either tangible measures (creation of intellectual property, start-up companies, spin-out enterprises, etc) or potential for commercialisation into new products/services/ technologies deployed to solve national needs.

iii. Robust management and governance, with adequate checks and balances, a clear structure of accountability, as well as reasonable milestones and deliverables.

iv. Reasonableness of the proposed budget.

## Estimated Budget and Maximum Project Duration

17. Funding support for each Research Proposal awarded will not exceed **S$1.5 million** for desktop[6] or bench scale studies and **$2.5 million** for studies involving field trials or pilot scale set ups. The Applicant should contribute in-kind services, cash, or a combination of the two towards the proposed project. In-kind services can include labour, materials, and other services. In-kind contributions demonstrate the participation and commitment of the applicants to the project.

[6] Modelling is considered as desktop study unless field trials or pilot scale set ups are conducted for data collection

**Maximum Project Duration**

18. The maximum funding period for the Research Proposal is **2 years** for desktop[6] or bench scale studies and **3 years** for studies involving field trials or pilot scale set ups.

**Point of Contact**

19. For more information, please contact Dr Peng Na (PENG_Na@pub.gov.sg) and Ms Yunita Tan (Yunita_TAN@pub.gov.sg) from PUB Singapore.

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**Appendix A**

## Areas of Study

The scope of the proposal should include the impact of climate change on (i) water quality and (ii) PUB's infrastructure in the next 10, 20 and 40 years. The proposal should specifically address some of the following listed areas and questions. In addition, the Applicant is free to propose other areas of study, *except for areas related to flooding and coastal protection* where separate studies are already ongoing.

## Impact to Water Quality

Local Water Catchment

- What is the quantitative impact of altered weather patterns (such as increased temperature, change in wind speed, increase in rainfall intensity & frequency etc.) on the following?
    - Nutrient loading
    - Algae growth and the production of toxic metabolites and taste and odour compounds
    - Microbial community of concern in Singapore's reservoirs (for water supply and recreational use)?
- There is a recognized increase in Natural Organic Matter (NOM) production with increase in water temperature. How would this impact water treatment processes?
- An increase in frequency and severity of algal blooms is expected with increase in water temperature. How could some early warning systems (of impending blooms) be improved to assist the water treatment process?

Seawater

- How will altered seawater quality (e.g. in terms of higher temperatures, altered salinity/conductivity, nutrient and/or chl-a concentrations etc.) impact the desalination process, specifically in terms of efficacy, efficiency and cost?
- An increase in frequency and severity of marine algal blooms is expected with increase in water temperature. How could some early warning systems (of impending blooms) be improved to assist the desalination process?
- What is the impact of biofouling activity with temperature increase on desalination processes?

NEWater

- How and to what extent will temperature increase impact the biological processes of the liquid and solid streams of used water treatment, including the efficiency and capacity of biogas generation?
- Is there an impact on membrane fouling in MBRs?

Network

- How will climate change quantitively impact the water quality in the water distribution network (e.g. whether it will hasten the depletion of residual chlorine)?

**Impact to Infrastructure**

- What is the quantitative impact on the rate of pipeline corrosion and failure?
- What is the quantitative impact on subsurface water flow and soil movement, and whether these can potentially cause pipeline failure?
- What is the impact on renewable energy infrastructure, i.e. solar panels for floating and rooftop applications?

## Appendix B

This Appendix provides information and findings from the 2nd National Climate Change Study and previous work by PUB with NUS Deltares and DHI. PIs shall build on the information provided as the basis for the proposed study.

### Overall approach

The projections of climate change at regional and local scale is generated by the global-scale projections produced by General Circulation Models (GCMs), which are mathematical models capable of representing the physical processes of the atmosphere and ocean to simulate response of global climate.

### Water quality of reservoirs[7]

The study concludes that climate change alone yields limited impact on the change of water quality, with slight decrease of phytoplankton biomass and dissolved oxygen concentrations. Increased water temperature driven by climate change accelerates the mortality, respiration, nitrification/denitrification and mineralization processes and may create combined effects and complex situation on water quality change in the reservoirs. More immediate and greater effects on water quality parameters would be due to future pollution emission scenarios as a function of human activities, urbanisation and hydrological characteristics at a catchment level. In other words, various emission sources over large spatial areas will affect the total external load for a range of key water quality parameters such as nutrients, bacterial, suspended solids and Biochemical Oxygen Demand (BOD).

The impact of different water treatment practices in the Marina Catchment and the impact of operational water resource management practices (including water recirculation) on water quality have been studied as well. The study showed that the water quality issues that may arise in the future cannot be controlled adequately only through the proposed water recirculation schemes. Emission reduction from human activities, urbanisation and other factors in the future through implementation of green measures would have the greatest effects.

### Algae[6]

Given the algal growth is limited by nitrogen and phosphorus as well as light, increased nitrogen or phosphorus may not necessarily lead to increase algal biomass, but this may lead to species composition shifts.

[7] Modelling of Reservoir Water Quality under the Effects of Climate Change, NUSDeltares

### Temperature of the reservoirs[6]

Studies on the temperature in the two of Singapore's reservoirs show an increasing trend and can potentially reach a maximum value of about 35°C over a period of 120 years. This is due to the increased air temperature and consistent with the finding by the recent Singapore's 2nd National Climate Change Study. The future climate change will have no significant increase in stratification at the bottom of the three shallow reservoirs in Singapore.

### Salinity intrusion[8]

Modelling tools, namely, MIKE SHE, FEFLOW and MIKE 3 have been set up as the reservoir models to project the salinity intrusion from seawater to coastal reservoirs in Singapore.

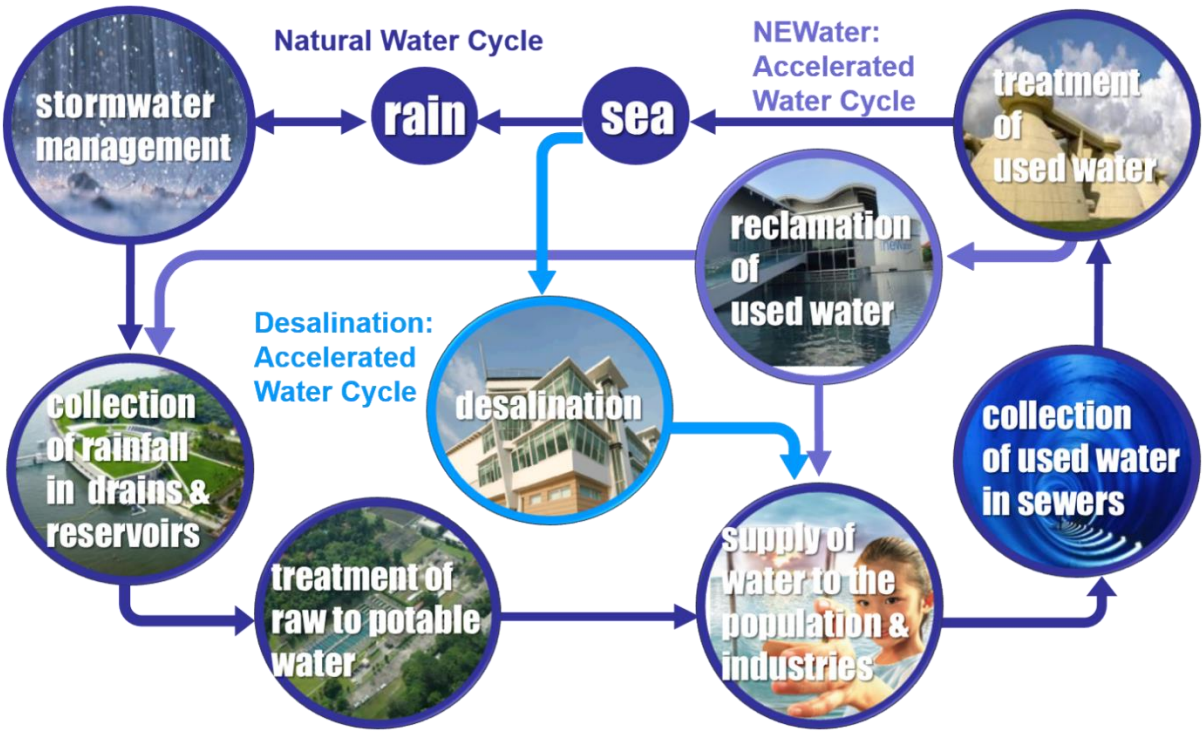
Salt intrusion is likely to take place during the projection period (2010-2099) and is more pronounced in the last 30-year period (2070-2099). Water quality in Jurong Lake, Kranji reservoir and Tengeh-Poyan reservoirs are not expected to be adversely impacted by the salt mass contribution from the various scenarios compared to the reservoir water quality measurements in 2014 and 2013. However, for Marina reservoir and Pandan reservoir, the last period in the +1 m sea level rise scenarios indicate a higher salt mass in the reservoir water.

The study concluded that the current inter-reservoir operating rules play a significant role in maintaining low salt intrusion throughout most of the whole projection period, as keeping the reservoirs at high water level most of the time is critical in minimising the rate of intrusion.

[8] Climate Change Impacts on Coastal Reservoirs in Singapore, DHI Water & Environment (S) Pte Ltd

**Appendix C**

**PUB's Water Loop**



## Annex A: Guidelines for Submission of Proposal on IGMS

**Closing Date: 26 November 2021, 4:00 pm** (Singapore time, GMT +08:00).

1. The preparation of the proposal should be done using the 'CWR Research Proposal Form' which can be downloaded from the online IGMS.

2. Applicants are required to lodge the application via the online IGMS before the stipulated closing date and time for the Request-for-Proposal (RFP). Separate submission outside of IGMS will not be considered. All relevant sections of the IGMS proposal online application form should be filled out completely, with the CWR Research Proposal Form and supporting documents uploaded as separate attachments. **The on-line application process may take time and hence please refer to IGMS website for full details of the application process. For new IGMS user from private companies, account registration is required for first time application. Please refer to Annex B below. New users would need to ensure his/her CorpPass account has been set-up, using his/her SingPass account.**

3. For submission of the proposal, it is necessary for all PIs and Co-PIs to sign up for an IGMS UserID. Co-PIs from the Partner Institutions shall be listed as "Team PI" in IGMS in order for the Partner Institutions to receive funding for the project.

4. Please note that applicants can only submit multiple files with maximum file size of 2MB each in the IGMS.

5. Should there be revisions to the submitted proposal, Lead PI is to delete previous submission(s) and only keep the final proposal in the system. Failing to do so may lead to evaluation of wrong version of the proposal.

6. The link to the online IGMS is given here: https://researchgrant.gov.sg

## Annex B: IGMS Account Creation

To facilitate the company accounts' creation, kindly provide the following to Ms Chay Peck Si (PUB_GLOBALHYDROHUB@pub.gov.sg) by **1 October 2021** to facilitate the registration process.

### Details of the New Company to be Created in IGMS

| S/N | Full Name of Company | Local Company / Foreign Company? | Public Company / Private Company? | UEN (for Local Company) / Unique Identifier (for Foreign Company) |
|---|---|---|---|---|
| **1** | | | | |
| **2** | | | | |

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### Procedures to create a new company account in IGMS:

Once the **new** company account is created in IGMS, the company will need to follow up on registration of the Host Institution (**HI) Admin** in IGMS.

### Creation of Users for "Local" Companies

**For new "Local" companies, the following steps will need to be done at the company:**

(1) The company will need to nominate a **HI Admin**.
(2) The **HI Admin** will need to ensure that his/her **CorpPass** account has been setup.
(3) The **HI Admin** will need to login to IGMS using his/her **CorpPass** account to **register/update** his/her profile inside IGMS. Please note that the IGMS would grant him/her the **Principal Investigator (PI)** role by default.
(4) After the **HI Admin** has been successfully registered in IGMS, the following details will need to be provided so that IGMS can change the role of the person from a **Principal Investigator (PI)** to a **HI Admin**:
   - **Full Name of HI Admin:**
   - **E-mail Address of HI Admin:**
   - **Designation of HI Admin in his/her company:**
(5) Once granted the role as a **HI Admin**, he/she can proceed to assign the relevant roles (i.e. Principal Investigator **"PI",** Director of Research "**DOR**", Office of Research "**ORE**") to the various users within his/her organisation.
(6) The system requires 3 different roles i.e. **PI**, **DOR**, and **ORE** for proposal submission. **HI Admin** and **PI** can be held by the same person, while **DOR** and **ORE** have to be held by 2 different people. As such, there are minimum 3 different personnel required for proposal submission in **IGMS**.

## Creation of Users for "Foreign" Companies

**For new "Foreign" companies, the following steps will need to be done at the company:**

(1) All users from the company (i.e. **HI Admin, DOR, ORE, PI)** will "**Register**" themselves in IGMS, with reference to the bottom of the "**Login for overseas users without CorpPass/SingPass**" section.

(2) After all the users have been successfully registered in IGMS, the **HI Admin** will need to provide the information below so that IGMS can **add** all the users, **tag** them to their foreign company, and **assign** the correct roles to all the users inside IGMS:

a. Full Name of **HI Admin**:
b. E-mail Address of **HI Admin**:
c. Designation of **HI Admin** in his/her company:
d. Full Name of DOR:
e. E-mail Address of DOR:
f. Designation of **DOR** in his/her company:
g. Full Name of ORE:
h. E-mail Address of ORE:
i. Full Name of **PI/s**:
j. E-mail Address of **PI/s**:

(3) The system requires 3 different roles i.e. **PI**, **DOR**, and **ORE** for proposal submission. **HI Admin** and **PI** can be held by the same person, while **DOR** and **ORE** have to be held by 2 different people. As such, there are minimum 3 different personnel required for proposal submission in **IGMS**.

(4) Once the above **Foreign Company users** have been added, tagged and assigned in IGMS, they can then proceed to login to IGMS via the "**Login for overseas users without CorpPass/SingPass**" section.

(5) **Note:** The **HI Admin** in the foreign companies cannot add a new user. However, the **HI Admin** in the foreign companies can change the role of a user, or, delete an existing user in his/her company.

**F**