ADB

Technical Assistance Consultant's Report

Project Number: 55064-002
February 2024

FA 100083: TA-6841 REG: Integrating Climate Resilience in the Water Sector - Greenhouse Gas Emission Accounting Specialist

Democratic Socialist Republic of Sri Lanka: Preparing a Climate Change Resilience Roadmap (CCRR) for the National Water Supply and Drainage Board (NWSDB)

CCRR Report: Final Report

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ABBREVIATIONS

ADB	Asian Development Bank
AE	Accredited Entity
AF	Adaptation Fund
CCG	climate corporate governance
CCIT	climate change and information technology
CCRR	Climate Change Resilience Roadmap
CDM	Clean Development Mechanism
CER	certified emission reduction
CH4	Methane
CO2	carbon dioxide
DMC	Disaster Management Centre
DOE	Designated Operational Entity
EB	Executive Board (for CDM)
EBRD	European Bank for Reconstruction and Development
ESU	environmental and social unit
FSM	fecal sludge management
FSTP	Fecal sludge treatment plant
GCC	Global Carbon Council
GCF	Green Climate Fund
GESI	gender equality and social inclusion
GgCO2e	gigagram carbon dioxide equivalent (= 1000 tons carbon dioxide equivalent)
GHG	greenhouse gas
GS	Gold Standard
HFC	Hydrofluorocarbon
IFI	International financial institution
IPPC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
IT	information technology
IWMI	International Water Management Institute
JCM	Joint Crediting Mechanism
KSTA	Knowledge and Support Technical Assistance
L&D	loss and damage
LDC	least developed country
LKR	Sri Lankan Rupee
LULUCF	land use, land use change and forestry
M&E	monitoring and evaluation
MEAL	monitoring, evaluation and learning
MFF	multi-tranche financing facility
MoWS	Ministry of Water Supply
MRV	measurement, reporting and verification
N2O	nitrous oxide
NA	not applicable
NAP	national adaptation plan
NDC	nationally determined contribution
NRW	non-revenue water
NWSDB	National Water Supply and Drainage Board
O&M	operation and maintenance
OSS	On-site sanitation

PBL	policy-based loan
PDD	Project design document
PES	payment for ecosystem services
PV	Photovoltaics
RE	renewable energy
RSC	Regional Support Center
SLCCS	Sri Lanka Carbon Crediting Scheme
tCO2e	tons of carbon dioxide equivalent
TBD	to be determined
TNA	technology needs assessment
TNC	third national communication
TOR	terms of reference
VCS	Verified Carbon Standard
WBS	Water Benefit Standard
WSS	Water Supply Scheme
WTP	water treatment plant
UNFCCC	United Nations Framework Convention on Climate Change

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EXECUTIVE SUMMARY

1. The background to the present assignment is provided by two Asian Development Bank (ADB) initiatives in Sri Lanka. First, ADB is considering a policy-based loan (PBL) "*Water Sector Reform Program*" to the water sector of Sri Lanka, of which the National Water Supply and Drainage Board (NWSDB) is a key part. Second, ADB is financing a related Knowledge and Support Technical Assistance (KSTA) named "*Democratic Socialist Republic of Sri Lanka: Strengthening the Institutional Capacity of the National Water Supply and Drainage Board*", for which a consultant firm (KSTA consultant) is being selected.

2. The current assignment is the first call off under a Framework Agreement for the services of the Greenhouse Gas Emission Accounting Specialist supported under Cluster TA (55064-001) "Mainstreaming Water Resilience in Asia and the Pacific". The assignment can be seen as preparatory for both the following KSTA and the PBL: providing upfront analysis, planning and road-mapping that provide direction to the following activities under both the KSTA and PBL which together will provide for the detailed elaboration and implementation of the outputs prepared under this assignment. In parallel to this assignment, a Digitalization Expert has been mobilized by ADB. Part of the assignment will be carried out by the Greenhouse Gas Emission Accounting Specialist acting individually (but with support from national experts) and part of the assignment is jointly with the Digitalization Expert.

3. According to the terms of reference (TOR) for the assignment and including slight rephrasing and interpretation as discussed in the inception report, the scope of the first call-off assignment will include, among others, developing a CCRR and related plans to increase Sri Lanka's NWSDB capacity to mainstream climate resilience and mitigation in its operations. The assignment consists of a data collection phase, a CCRR development phase, and jointly with the Digitalization Expert, preparation of a combined climate change and information technology (CCIT) plan for processes and procedures for measurement, reporting and verification (MRV) and monitoring, evaluation and learning (MEAL). All NWSDB activities are in principle to be covered in the latter, including water supply and sanitation up to treatment and disposal of wastewater.

4. This final report covers the data collection phase and the use of the data collected for the preparation of the CCRR and incorporates changes in the report responding to comments made by both ADB and NWSDB on the revised draft report. This final report will be accompanied by a separate report on the CCIT development plan.

Figure ES1. Four steps-methodological approach to the assignment.

5. The methodology for this assignment will follow four steps, as illustrated in Figure ES.1, with stakeholder consultations integrated throughout the four steps. The first three steps are

covered in this final CCRR report, while the fourth step will be covered in the separate CCIT report.

6. This report first takes stock of the climate issues at NWSDB by preparing 1) an overview of the sources of GHG emissions at NWSDB 2) an overview of the climate change challenges requiring adaptation actions. See respectively Table 1 and Table 7, to which we refer for details.

7. Total GHG emissions are estimated at 214,911 tCO2e per year, or almost 215 thousand tCO2e. Of this amount, the most important sources are GHG emissions from power consumed[1] (177,013 tCO2e/year) and GHG emissions from the use of diesel in vehicles (30,829 tCO2e/year).

8. The main NWSDB climate-related challenges are summarized below:

Increased temperatures
1) Increased risk to health through increased spread of pathogens
2) Increased evaporative losses from water sources
3) Increased demand for water may put stress on the NWSDB supply system

Sea level rise
4) Increased saltwater intrusion;
5) Lower quality water resources due to increased salinity requiring more and more costly treatment
6) Increased risk to health

Increase in precipitation or increased frequency of extreme precipitation events and storm Surges
7) Increased risk of flooding resulting in damage to NWSDB operations and assets.
8) Increased risk of damage due to flooding and/or landslides
9) Increased risk of rising water tables exposing underground structures to ground movements and flotation, which could cause structural damage and inundation; increased risk of septic tanks and pit latrines flooding or filling with silt.
10) Increased risk to health through increased spread of pathogens
11) Danger to users of NWSDB buildings resulting from flooding and/or landslides
12) Intake blockages due to silt and floating objects
13) Inaccessibility to operators of NWSDB Intakes / buildings resulting from flooding.
14) Additional treatment costs due to poor source water quality
15) Power failures due to extreme weather
16) Increased risk of source water quality depletion resulting plant shutdown and revenue loss
17) Interruption of source water extraction due to dislocation of floating intakes

Drought
18) Increased risk to temporary shortages of water in drought periods.
19) Decrease in surface and groundwater availability
20) Water scarcity
21) Increased water demand
22) Increased competition with other water users
23) Water quality deterioration due to low dilution and algae proliferation.

[1] Electrical power is mainly used for pumping water; other uses of electrical power only account for minor shares in power consumption.

24) Additional cost for water treatment, increased pumping and bowser supply
25) Increased saltwater intrusion due to low flow in rivers
26) Difficulty of source water extraction using floating intakes
27) Diversion of flow of rivers from direct intake locations
28) Low pressure in distribution systems due to increased water consumptions

9. On the basis of these assessments, longlists of potential mitigation and adaptation measures were prepared, which were then narrowed down to shortlists of proposed mitigation and adaptation measures. A list of accompanying soft measures was prepared on the basis of a climate corporate governance assessment, NWSDB's NDC commitments, and experience. The proposed specific actions of the CCRR are described in three tables, Table 10 for mitigation investments, for adaptation investments, and Table 16 for accompanying soft measures.

10. The proposed mitigation actions are presented below. It consists of a mix of studies related to mitigation investments (which may lead to subsequent investments) and investments, with the expected mitigation estimated at 81,174 tCO2e/year (over 81 thousand tCO2e)[2].

Proposed mitigation actions – short-term[3]
1. Study on options to reduce technical water losses
2. Increased pumping efficiency
3. Solar PV investment
4. Investigation of options to mitigate GHG emissions from wastewater treatment and fecal sludge management.
5. Catchment Protection and awareness programs

Proposed mitigations action – Medium-term
6. Reduction of technical water losses – implementation of identified investments leading to the targeted reduction in water losses
7. Implementation of identified mitigation measures in the wastewater sector
8. Study on the suitability of biodiesel NWSDB diesel engines.
9. Study on the feasibility of renewable energy other than solar PV

Proposed mitigation actions – Long-term
10. Implementation of a switch from diesel to biodiesel – provided biodiesel becomes available and the study mentioned under point 7 directly above is positive.
11. Implementation of identified renewable energy options other than solar PV that have adequate payback periods.

11. Below the proposed adaptation investments are presented with an indication of their priorities (short-term, medium-term and long-term) considering urgency of action and existing NWSDB commitments. This prioritization in time will need to be confirmed and, if necessary, modified by NWSDB. Note that systematic collection of climate relevant data is important to inform adaptation investment decision-making. This has been included as a first priority soft measure as discussed below (Next paragraph, item XXIV).

Proposed adaptation investments

[2] In ADB terminology, these are negative relative emissions – also known as emission reductions.
[3] Short-term, Medium-term, Long-term periods are considered as 5, 10 and 25 years respectively.

Short-term

1) Reducing System Water Losses
2) Increasing Source Water Availability/Quality
3) Solving User Conflicts
4) Promoting Efficient Water Use, Motivation Reuse,
5) Implement Energy auditing and replacement
6) Implement NWSDB's part of the sanitation master plan[4].
7) Planning of upstream reservoirs
8) Identify best solutions for flood and drought mitigation (covering technical and financial aspects).
9) Monitoring and recording of saline water intrusion into drinking water sources especially during drought periods.
10) Completion of ongoing new drinking water projects
11) Seek new water sources and options – Surface and sub-surface water
12) Promoting of rainwater harvesting and ground water recharging
13) Implement new drinking water projects
14) Seek new water sources and options – Surface and sub-surface water
15) Prepare, Review, update and prepare disaster management plans and emergency evacuation plans for buildings and Water infrastructure located in flood-, landslide- or tsunami-prone areas.

Medium-term

16) Increasing Water Supply and Sanitation Coverage
17) Promote Recycled Water and Rain Water for Non Potable Use
18) Increasing Source Water Availability
19) For new operational assets and buildings especially in areas with elevated risks of floods, landslides and tsunamis, make siting decisions that lower or eliminate these risks.
20) Establish salinity barriers at each critical river identified.
21) Construct protective measures (grey and green) to protect buildings and operational assets that are sited in areas with elevated risks of floods, landslides and tsunamis.
22) Use of flood resistant materials such as corrosion- and water resistance materials in new constructions

Long-term

23) Increase shading of storage facilities.
24) Use non-traditional sources of water, such as treated wastewater, treated brackish water and desalinated seawater.
25) Ground Recharge of Treated WW
26) Increase in Source Water Availability
27) Construction of upstream reservoirs for drinking water.

12. Finally, the proposed accompanying soft investments have been included below. Most of these are first priority (short-term), but items 13 to 19 are second priority (medium-term), and items 20-24 are third priority (long-term).

Proposed accompanying soft investments

[4] Existing and planned support by donors needs to be assessed.

1) Commit to periodically disclose information on our direct GHG emissions (Scope 1) and indirect GHG emissions from energy use (Scope 2) externally using internationally recognized methodologies and guidance.
2) Commit to periodically disclose information related to low-carbon transition climate risks and opportunities using internationally recognized methodologies and guidance.
3) Commit to periodically report about the climate-related risks and opportunities (low-carbon transition and physical impacts) the organization faces and to validate the process internally.
4) Appoint a member of the board or senior management with specific responsibility for climate related risks and opportunities, including policy, strategy and information.
5) Apart from building staff capacity, take measures to develop and enhance the board's and executive management's collective knowledge of and resources for climate risks and opportunities identification.
6) Regularly conduct stakeholder consultations to identify and manage economic, environmental, and social risks (with climate risks and opportunities considered a subset of these). Relevant results are communicated to stakeholders (external and internal) in a transparent way.
7) Develop and publicly communicate a climate-related strategy / policy and formulate climate-related targets.
8) Develop and put in place a process to assess climate-related risks and opportunities, including the use of multiple climate scenarios, for multiple timeframes to cover risks and opportunities. These assessments will include consideration of direct and indirect risks and opportunities, specifically those that may manifest themselves through the value chain. Risk management actions will systematically be identified for the priority climate-related risks and opportunities.
9) Commit to disclose quantitative and qualitative information related to physical climate risks and opportunities using internationally recognized methodologies and guidance.
10) Implement regulatory measures for water fittings.
11) Prepare plans for building capacity in each institution to effectively implement the sector NDCs including that of community water supply schemes.
12) Awareness raising and behavioral change campaigns for the public towards sustainable use of water as a climate resilience building for water security.
13) Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities.
14) Review, update and prepare disaster management plans and emergency evacuation plans for buildings in flood-, landslide- or tsunami-prone areas.
15) Creating and maintaining a database of NWSDB assets including water and sanitation infrastructure and buildings.
16) Improve data collection and forecasting capabilities.
17) Develop climate information services and early warning systems.
18) Enhancing the implementation of Climate Resilient Water Safety Plan and Sanitation Safety plan
19) Good Stakeholder coordination for increase water use efficiency programme
20) Increase QA/QC for new Projects
21) Catchment Protection Programmes and WQ surveillance
22) Research & Development studies and Piloting outcomes
23) Energy Auditing/ Monitoring of Specific Energy Consumption (SEC) of All Water Supply Schemes
24) Implement the CCIT development plan including the development of a database to track climate change related parameters and impact to water infrastructure and consumers to

arrive in adaptation decisions. See the accompanying report on the CCIT development plan.

13. The proposals / recommendations mentioned above will need to be validated with NWSDB management before they can be acted upon. For example, NWSDB management may want to remove some of the proposals, add others, and modify some of the proposals. All such changes are welcome. Also, NWSDB management may go to set priorities in time for the various actions different from the proposals in this report.

14. When it comes to financing, NWSDB likely would want to include their cost estimates and reflect what financing is already secured from sources such as the government of Sri Lanka and international financial institutions (IFIs). Nevertheless, it is likely that a large amount of new financing will be needed to finance the proposed actions, as modified. A first estimate would be over $60 million for mitigation, over $400 million for adaptation, and $2 million for accompanying soft measures.

15. For various reasons it will be difficult to fill these financing requirements from traditional sources. Sri Lanka's macroeconomic financial situation is not very good, so that it will be difficult to attract financing from e.g. international financial institutions. Moreover, the adaptation investments will not lead to additional revenues that can be used to repay loans, while the mitigation investments mostly will result in either cost savings or revenues that are both in local currency, which does not help service loan nominated in hard currencies.

16. To address these issues, the report makes two recommendations that are elaborated upon in more detail in Section IX. The first is to secure a financing facility for which the commitments are spread out over time, so that each commitment by the government of Sri Lanka becomes smaller and is easier entered into. ADB's multi-tranche financing facility is such a financing facility. The second recommendation is to seek highly concessional GCF funding for the implementation of the CCRR. Approaching the GCF requires coordination within the government of Sri Lanka and identifying an interested Accredited Entity (AE), an entity recognized by the GCF as a valid intermediary. Section IX provides detailed suggestions for approaching potential AEs.

17. Finally, at the request of NWSDB, the potential for using carbon credits was explored. Table 17 and the accompanying text provide the main recommendations. Here we summarize Table 18 and include the accompanying text.

18. In principle, for any investment leading to GHG emission reductions, the mechanism for monetization of the carbon credits is in order of preference first Article 6.2, second Article 6.4, and third VCS or Gold Standard. The exception is emission reductions thanks to the reduction of technical water losses, for which the Sri Lanka Carbon Crediting Scheme is recommended.

19. When NWSDB decides to implement one or more of the proposed mitigation actions, the following steps are recommended if NWSDB wishes to gain revenues from the sale of carbon credits:

- Appoint a consultant with considerable carbon market experience to advise on whether entering the carbon credit development trajectory is advisable (market conditions change rapidly, so the current analysis may become outdated).
- Explore the recommended standards and update the recommended standard if appropriate.

- Where several standards are indicated, these are listed in order of priority to be explored. The general order of priority is Article 6.2, followed by Article 6.4, followed by voluntary market standards.
  - Currently Article 6.2 is operational, and several bilateral are in the market for carbon credits under Article 6.2 (for example, Japan, Norway, Singapore, and Switzerland).
  - If a transaction under Article 6.2 cannot be identified, it makes sense to next explore Article 6.4. Article 6.4 is not yet operational; therefore two things will need to be checked on the Article 6.4 website[5] with priority: 1) Whether the multilateral mechanism has become operational; and 2) whether an approved methodology exists for the project type.
  - If both Article 6.2 and Article 6.4 are unavailable, next the international voluntary market standards are explored. For renewable energy the recommended standard is the GCC standard (VCS and GS do not apply to solar PV in Sri Lanka, with the exception of floating solar), while for energy efficiency VCS and Gold Standard are recommended as equal options.
  - It should be noted that at least in the case of VCS and Gold Standard, there are pathways to start a project under the VCS and Gold Standard and then move it later under the Article 6 mechanism.
- In the case of reduction in water losses leading to GHG mitigation, the recommendation is to use SLCCS if any carbon credit development is pursued. The reason for this recommendation is that the project is too small for the recognized international standard, combined with the difficulty of finding appropriate methodologies for the quantification of the emission reductions in line with the requirements of the standards.

20. To create the milestones for the proposed CCRR, the following steps are proposed:

- First, when approving the CCRR action plan, comprising the mitigation action, adaptation investments, and accompanying soft investments (as described above, with possible modifications), NWSDB also need to decide on the timing for the completion of the investments and other actions. This needs to take into account NWSDB priorities and commitments.
- From the completion time, calculate backwards when the actions need to be initiated (e.g., commencement of construction, start of capacity building activities). This creates a second milestone.
- From these milestones for the initiation of the CCRR actions, it is possible to work backward to other action specific milestones, which capture the processes for the approval and implementation of investment and capacity building activities at NWSDB.
- These three steps define a series of milestones for the implementation of the CCRR, against which the progress in implementing the CCRR can be monitored.

[5] https://unfccc.int/process-and-meetings/bodies/constituted-bodies/article-64-supervisory-body

I. INTRODUCTION

A. Background

1. The background to the present assignment is provided by two Asian Development Bank (ADB) initiatives in Sri Lanka. First, ADB is considering a policy-based loan (PBL) "*Water Sector Reform Program*" to the water sector of Sri Lanka, of which the National Water Supply and Drainage Board (NWSDB) is a key part. Second, ADB is financing a related Knowledge and Support Technical Assistance (KSTA) named "*Democratic Socialist Republic of Sri Lanka: Strengthening the Institutional Capacity of the National Water Supply and Drainage Board*", for which a consultant firm (KSTA consultant) is being selected.

2. The PBL[6] covers two reform areas, one of which is '*Climate-resilient, safe, inclusive, and environmentally sustainable water supply systems management strengthened.*' This reform area covers as policy actions among others:

- The establishment of an environmental and social unit (ESU) with fully staffed and qualified personnel, to strengthen and ensure that NWSDB's activities are environmentally sustainable, socially inclusive, gender responsive, and are climate and disaster risk resilient.
- The approval and start of the implementation of a Climate Change Resilience Roadmap (CCRR) towards mainstreaming resilience with short-, medium-, and long-term actions for climate resilience.

3. The KSTA[7] has 2 outputs: Output 1 "*Organizational road maps and action plans for enhancing NWSDB financial sustainability and operational efficiency developed*" and Output 2 "*Capacity of NWSDB strengthened*".

- Output 1 among others comprises the preparation of the NWSDB ESU mandate including gender equality and social inclusion (GESI) related provisions, women's representation (at least 30%) and one woman with management role in the ESU structure.
- Output 2 among others comprises (a) capacity development to ESU on climate change assessments and management and (b) development of a capacity-building program and investment plan that includes the provision of IT hardware and software for (i) measuring, reporting, and verifying climate change actions; and (ii) monitoring and evaluating systems that support mitigation, adaptation, and loss and damage.

4. The current assignment is the first call off under a Framework Agreement for the services of the Greenhouse Gas Emission Accounting Specialist supported under Cluster TA (55064-001) "Mainstreaming Water Resilience in Asia and the Pacific". The assignment can be seen as preparatory for both the following KSTA and the PBL: providing upfront analysis, planning and road-mapping that provides direction to the following activities under both the KSTA and PBL which together will provide for the detailed elaboration and implementation of the outputs prepared under this assignment. In parallel to this assignment, a Digitalization Expert has been mobilized by ADB. Part of the assignment will be carried out by the Greenhouse Gas Emission Accounting Specialist acting individually (but with support from

[6] ADB. 2022. Proposed Programmatic Approach and Policy-Based Loan for Subprogram 1 and Technical Assistance Grant. Democratic Socialist Republic of Sri Lanka: Water Sector Reform Program. Concept Paper, Project Number 56281-001.

[7] ADB. 2022. Knowledge and Support Technical Assistance (KSTA). Democratic Socialist Republic of Sri Lanka: Strengthening the Institutional Capacity of the National Water Supply and Drainage Board. Technical Assistance Report, Project Number 52246-002.

national experts, see below) and part of the assignment is jointly with the Digitalization Expert.

5. According to the terms of reference (TOR) for the assignment and including slight rephrasing and interpretation as discussed in the inception report, the scope of the first call-off assignment will include, among others, developing a CCRR and related plans to increase Sri Lanka's NWSDB capacity to mainstream climate resilience and mitigation in its operations. The assignment consists of a data collection phase, a CCRR development phase, and jointly with the Digitalization Expert, preparation of a combined climate change and information technology (CCIT) plan for processes and procedures for measurement, reporting and verification (MRV) and monitoring, evaluation and learning (MEAL). All NWSDB activities are in principle to be covered in the latter, including water supply and sanitation up to treatment and disposal of wastewater.

6. This final report covers the data collection phase and the use of the data collected for the preparation of the CCRR and incorporates changes in the report responding to comments made by both NWSDB and ADB on the revised draft report. This final report will be accompanied by a separate report on the CCIT development plan.

B. Purpose of the CCRR

7. The CCRR serves the following purposes:

- Assessment of current climate change vulnerabilities.
- Identification of adaptation investment options to address climate change vulnerabilities. These are ‘hard’ investments in assets or physical capital, as opposed to ‘soft’ investments (capacity building, organizational and institutional development.
- Assessment of current carbon footprint.
- Identification of (hard) greenhouse gas mitigation investment options to reduce the carbon footprint.
- Identification of soft measures to accompany the adaptation and mitigation investment options.

8. By addressing these purposes, the development of the CCRR will provide the following benefits:

- Identification of attractive GHG mitigation investments options and their financing. Attractive in the context has several meanings:
  - Attractive based on the reduction of costs, with a relatively short payback period for suggested investments,
  - Attractive based on monetization of GHG emission reductions (carbon credits, Article 6),
  - Attractive based on concessional finance options
- Identification of attractive adaptation options and their financing, where attractivity takes the form of either:
  - Avoidance of expected climate change related costs exceed adaptation investment costs, or
  - Mobilization of concessional finance to reduce the investment costs for NWSDB.
- Development of climate corporate governance structures (linked to ESG principles) (see next topic) so that over time, NWSDB will be able to prepare CCRRs and its components (including climate change risks and opportunities for identification, preparation of adaptation and mitigation action plans) on its own and make gradual improvements in its processes.

- Allow NWSDB to play a key role in fulfilling Sri Lanka's intended international climate change contributions.
- Allow NWSDB to take a leadership role and become a role model for climate action in Sri Lanka and the region.

C. Set up of the report

9. This report is set up as follows. Section II outlines the methodology for the assignment. Section III provides the GHG inventory of NWSDB. Section IV describes the climate change challenges to which NWSDB is exposed. Section V discusses mitigation options and arrives at a list of proposed mitigation options. Section VI discusses adaptation options and arrives at a list of proposed adaptation options. Section VII discusses soft measures that could complement the hard investments proposed in Sections V and VI. Section VIII discusses the role of carbon credits. Section IX discusses the financing plan, and Section X provides the conclusions.

II. METHODOLOGY

10. The methodology for this assignment will follow four steps, as illustrated in **Error! Reference source not found.**, with stakeholder consultations integrated throughout the four steps[8]. The first three steps are covered in this final CCRR report, while the fourth step will be covered in the separate CCIT report. Therefore, the following steps will be discussed in turn: Section A discusses the data and information collection, Section B discusses the preparation of the CCRR, and Section C discusses how CCG can be used to provide a framework for continuous improvement.

Figure 1. Four steps-methodological approach to the assignment.

A. Data and information collection

11. The first step in the methodology consists of data and information collection. The main focus is (1) on the operational assets (including here and below the water supply schemes) and buildings of NWSDB and their location, to identify what climate change related risks these might be exposed to (using hazard maps and climate change projections) and later to identify appropriate adaptation options, and (2) on the energy consumption of the main operational assets and buildings and the incorporation of specific technologies, so that GHG emissions and later GHG mitigation opportunities can be identified.

12. To implement the data collection, a data and information request was prepared, focusing mainly on 5 topics as summarized below, also indicating later uses of the information to be collected:

- Information about buildings and operational assets (including vehicles), with focus on energy uses and technologies used. Later use: identification of mitigation options.
- Information about location of buildings and operational assets and sources of water, to identify climate related risks these are exposed to[9]. Later use: identification related adaptation options.
- Water balance, with a focus to understand mitigation and adaptation options.
- Studies and reports, including among others a review of past capacity building programmes and training activities, but also including studies and reports to identify mitigation and adaptation options, to identify climate related risks, mitigation options, and capacity gaps.
- Information of past investments in adaptation, mitigation, and closing capacity gaps.

13. Initially the focus of the data and information request was NWSDB wide. However, based on the large number of water schemes (334 according to information collected from

[8] Awareness raising is not a task under this assignment but could be a potential task for the KSTA consultant. Knowledge management is integral to the MEAL focus on the CCIT plan but is mostly a potential task for the KSTA consultant.

[9] See Section IV for the main climate related hazards identified from the sources consulted. Not all of these hazards will be relevant for all operations, water sources, buildings and other assets. The location of each of the operations, water sources, buildings and other assets will be important to assess to which hazard each individual element analyzed will be exposed to.

NWSDB) and buildings (more than 1000) of NWSDB, it was decided to focus on a stratified sample of the water schemes and buildings and to mobilize a national consultant to assist in the collection of information and data.

14. Based on the decision to use a stratified sampling methodology, the data and information request was redrafted and discussed during a meeting on 20 January 2023. During this meeting it became clear that the data and information request had to be redrafted a third and later a fourth time (including the stratification proposed based on the information received up to 25 February 2023). See Annex 1 for the final version[10].

15. Data was collected until October 2023, and included data collected during a visit to Sri Lanka by the Greenhouse Gas Emission Accounting Specialist from 17 September to 24 September 2023.

B. CCRR preparation

16. Based on the data and information collected, the development of the CCRR first focuses on the hard (physical) investments and soft practices that could be identified to address climate change risks and reduce GHG emissions. After that soft institutional and capacity development actions are identified. The identification of hard investments and soft practices proceeds according to several sub-steps:

- Enumerating the operational assets, water sources and buildings that are at risk from climate, including the specific hazard(s) to which each is exposed – first for the sample, then extrapolated NWSDB-wide.
- Identifying investments (mostly hard investments, but also some soft practices) that could address the identified risks. This will be done on the basis of various sources, including the knowledge and experience of the Greenhouse Gas Emission Accounting Specialist, but also through consultations of several information sources, such as the various National Adaptation Plans (NAP, including the NAP of Sri Lanka[11]), the various Technology Needs Assessments (TNA, including the TNA of Sri Lanka[12]), funding proposals submitted to and approved by the Green Climate Fund (GCF) and the Adaptation Fund (AF), and various reports including reports prepared for ADB[13]. Additionally, the data and information request in Annex 1 specifically asks about adaptation measures that have been identified by NWSDB[14].
- Estimate GHG emissions for the sample of operational assets and buildings, followed by the extrapolation of the GHG emissions NWSDB-wide. This step may not be strictly needed but is useful to understand to what extend meaningful GHG emission reductions may be achieved at NWSDB. Box 1 provides further information on how GHG emissions were calculated.

[10] Earlier versions of the data and information request have not been included in this inception report to reduce the length of the document but are available on request.
[11] Climate Change Secretariat. 2016. National Adaptation Plan for Climate Change Impacts in Sri Lanka. Climate Change Secretariat, Ministry of Mahaweli Development and Environment, Sri Lanka.
[12] Climate Change Secretariat. 2014. Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation. Climate Change Secretariat, Ministry of Environment and Renewable Energy, Sri Lanka, and Climate Change Secretariat. 2014. Technology Needs Assessment and Technology Action Plans for Climate Change Mitigation. Climate Change Secretariat, Ministry of Environment and Renewable Energy, Sri Lanka.
[13] ADB. 2014. Technologies to support climate change adaptation.
[14] An initial list of adaptation measures that could be considered has been included in Annex 4 for information purposes. This list is not meant to be complete so that more measures could be added, while measures that have been included do not necessarily need be part of the adaptation action recommendations. The purpose of this Annex is mostly to reflect suggestions received from NWSDB.

- Identification of hard investments and soft practices that may reduce GHG emissions and at the same time may be expected to have a reasonable cost. This identification will be based on the various TNAs and funding proposals submitted to the GCF, but will also benefit from a proprietary database of mitigation technologies that the Greenhouse Gas Emission Accounting Specialist has access to. Additionally, the data and information request in Annex 1 specifically asks about mitigation measures that have previously been identified by NWSDB, for example through energy audits. Estimates of emission reductions that may be achieved from the implementation of the identified measures will be included.

Box 1. Calculation of GHG emissions and GHG emission reductions

GHG emissions and GHG emission reductions could be assessed for fuel use (mainly diesel and gasoline) and for the use of electric power.

- For diesel and gasoline, amounts of fuel consumed (expressed in liters per year) were converted to amounts of primary energy supplied through multiplication by the net calorific value (NCV), 32.0 MJ/l for gasoline and 36.0 MJ/l for diesel[15]. Primary energy inputs were converted to CO2 emissions (expressed in tCO2 per year) through multiplication by emission coefficients[16] (69.3 tCO2/TJ for gasoline and 74.1 tCO2/TJ for diesel) and division by 1 million to convert from MJ to TJ.
- For electrical power, emissions were calculated by multiplying the amount of grid-supplied power consumed (expressed in MWh per year) by 0.5059 tCO2/MWh, the grid emission factor for firm energy. Emission reductions were calculated using reductions in grid-supplied power consumed (expressed in MWh per year), multiplied by 0.5059 tCO2/MWh, the grid emission factor for firm energy, in the case of energy efficiency and water loss reduction projects, and multiplied by 0.6464 tCO2/MWh, the grid emission factor for intermittent energy, in the case of solar PV projects[17].

Although covered in the information request, no information could be collected on wastewater treatment and methane (CH4) and nitrous oxide (N2O) emissions resulting from wastewater treatment, so that no calculations could be conducted to assess these emissions. For that reason, we have included a PM item in the calculated greenhouse gas emission inventory.

During the September visit to NWSDB, it was confirmed that NWSDB CH4 and N2O emissions from wastewater treatment likely are very low, because:

- Only a small fraction of households (2.1% in 2020) are connected to sewerage systems and central treatment of wastewater. The vast majority of households (91.5% in 2020) use what is called non-sewered sanitation (NSS) or ‘on-site’ sanitation (OSS) in below-ground storage tanks near the toilets, which should in principle be serviced to empty the tanks from the fecal sludge that accumulates.
- Mixed ownership and responsibilities for wastewater treatment plans and fecal sludge treatment plants, involving NWSDB but also (mainly but not exclusively) Local Authorities.
- Significant reliance on aerobic treatment technologies.

[15] https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html.
[16] IPCC (2006), 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. Chapter 3. Mobile Combustion. Table 3.2.1., as amended from time to time. See: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf.
[17] All grid emission factors are from IFI Dataset of Default Grid Factors v.3.2, used by IFIs GHG reporting. See: https://unfccc.int/sites/default/files/resource/Harmonized_IFI_Default_Grid_Factors_2021_v3.2_0.xlsx.

Despite the above, it is worthwhile to make a comprehensive assessment of GHG emissions due to NWSDB-owned wastewater treatment plants and fecal sludge treatment plants to precisely assess current emissions and emissions from planned treatment facilities (see below) which may be important for adaptation purposes and could offer significant emission reduction potential.

17. The above provides the core to the CCRR, a list of potential adaptation and mitigation measures that could be implemented with an initial costing. The KSTA consultant will need to review this list and conduct due diligence on these proposed measures, among others including a financial and economic analyses of the identified measures. Of course, NWSDB will make the final decisions as to what proposed measures to implement.

C. CCG framework for continuous improvement

18. The CCG framework, developed by European Bank for Reconstruction and Development (EBRD), assesses climate corporate governance along 7 dimensions and scores performance on each dimension against a 4-point scale: basic, intermediate, advanced, and best practice. The 7 dimensions are:

- Commitment. Information on climate-related strategy, policy or targets.
- Accountability: Description of where oversight or accountability on climate-related issues reside, and whether there are specific incentives in place.
- Processes: Does the organization assess climate-related risks and opportunities and prepare action plans to address these risks and opportunities? How? For climate finance purposes, this is key.
- Capacity: Does the organization have technical, financial or personnel resources allocated to the identification of climate change-related issues and does it provide training on these aspects? How?
- Engagement: Does the organization engage with stakeholders to support the work of our board and executive management around economic, environmental and social topics and their impacts, risks and opportunities? How?
- Disclosure: Does the organization disclose information related to 1) GHG emissions, 2) low-carbon transition risks and opportunities, and 3) climate-change related physical risks and opportunities externally? How?
- Validation: What are the organization's processes for validating the consistency and robustness of climate-related data, information and reporting processes?

19. Details on the scales for each dimension of the CCG are included in Annex 2. This also provides the instrument that was used to collect self-assessment opinions of senior NWSDB management on the seven dimension of climate corporate governance. The self-assessments collected were used to assess the soft measures that could be taken to improve governance (for confirmation, validation and elaboration by the KSTA consultant), but on the other hand also provides a framework that can be used for continuous improvement. The latter use of the CCG framework involves periodically selecting CCG dimensions along which NWSDB can improve to the next level, so that after a few iterations, NWSDB may have reached best practice for most if not all dimensions. This is illustrated in Figure 2.

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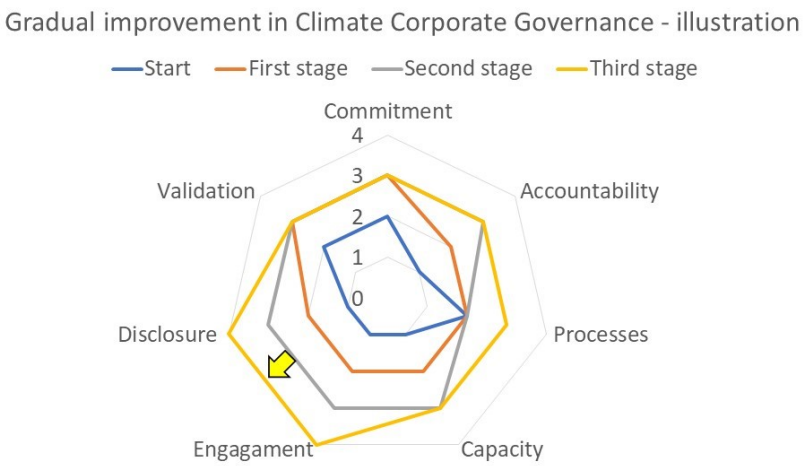


Figure 2. Use of the CCG framework for continuous improvement.

III. GREENHOUSE GAS EMISSIONS OF NWSDB

20. GHG emissions at NWSDB are summarized in Table 1. The vast majority of the GHG emissions are due to the use of electrical power supplied by the grid, mostly for the pumping of water. This is a scope 2 emission source. Additional significant sources of GHG emissions are the use of fuels by vehicles, mostly in the form of diesel. A potentially significant source of GHG emissions is the use of diesel for generators, however, subject to considerable uncertainty as discussed below. Furthermore, as discussed in Box 1, N2O and CH4 emissions from wastewater treatment could not be assessed but are likely low. All of these emissions are scope 1 emissions.

Table 1. GHG emissions of NWSDB.

Source of GHG emissions	Key input value	Estimated GHG emissions (tCO2e/yr)
Diesel for vehicles	11,556,789 liters/yr	30,829
Gasoline (petrol) for vehicles	339,938 liters/yr	754
Diesel for generators (upper limit)	70,560 kW	18,229
Diesel for generators (lower limit, preferred value)	70,560 kW	6,396
CH4 emissions from wastewater treatment	NA	PM
N2O emissions from wastewater treatment	NA	PM
Total scope 1 emissions[18]		***37,979***
Grid power consumed	349,928 MWh/yr	177,013
Total scope 2 emissions		***177,013***
Total emissions[19]		**214,991**

NB. Figures may not add up due to rounding.
tCO2e = tons of carbon dioxide equivalent; CH4 = methane; kW = kilowatt; MWh = Megawatt hour; N2O = nitrous oxide; NA = not available; PM = pro memoria; yr = year
Source: Author's calculations and estimations.

21. Vehicle fuel consumption was estimated on the basis of NWSDB vehicle fleet data, which provided information on the type of vehicles, type of fuel used (diesel or gasoline), and the number of vehicles, as well as estimated fuel efficiency. These data were combined with assumptions on annual milage to estimated fuel use. Some of the regional support centers provided information on the actual milage, and where such information was available, fuel use for a vehicle type was based on the actual milage rather than assumed milage (although the difference between the two was small). Additionally, for mobile equipment fuel use was estimated based on fuel use per hour (provided by some of the regional support centers) and assumed annual operating hours. Calculated use per vehicle type was summed to obtain the total fuel use, NWSDB wide.

22. Estimated fuel use was used to calculate GHG emissions using the procedure set out in Box 1. Diesel use by vehicles is a significant source of GHG emissions at 30,829 tCO2/year. Emissions from petrol are small, at 754 tCO2/year.

23. The central data point for generators is their total capacity, 70.56MW, but without further information, this cannot be translated into GHG emissions. Some regional support centers provided additional information in the form of hourly diesel consumption at full capacity and total annual diesel consumption. This information can be used to calculate GHG emissions from generators in two different ways:

[18] Only the lower limit is shown, as this is the preferred value. The upper limit, assuming the higher estimate for GHG emissions from use of the generator, is 49,812 tCO2/year.
[19] Only the lower limit is shown, as this is the preferred value. The upper limit, assuming the higher estimate for GHG emissions from use of the generator, is 226,825 tCO2/year.

- From the total annual diesel consumption and the hourly fuel consumption at full capacity, the annual effective operating hours (322.9 hours/year) can be calculated. Multiplication of the total generator capacity with this number provides an estimate of total power generated. Applying an emission factor of 0.8 tCO2/MWh[20] for off-grid power generation through diesel generators, the total GHG emissions from power generation can be calculated, 18,229 tCO2/year.
- From total annual diesel consumption and total generation capacity in the sample for which data were available, average diesel consumption per MW could be calculated (33.98 liter per kW). This number can be applied to the total generator capacity and combined with the NCV and CO2 coefficient (both see Box 1) to calculate CO2 emissions. This approach leads to the much lower estimate of 6,396 tCO2/year.

24. Of the two approaches mentioned above, we believe the second is the preferred option. A mistake in the annual amount of fuel used is less likely than in the amount of fuel needed at full capacity; the number of explicit and implicit assumptions is lower; and general speaking, back-up generators are used quite sparingly, so that an estimate of over 300 hours of use per year would be unexpectedly high. Therefore, we have used the estimate of 6,396 tCO2 emissions from generators in the remainder of this document.

25. As mentioned, no data has been provided that can be used for the calculation of CH4 and N2O emissions from wastewater treatment. As noted, wastewater treatment mostly uses aerobic treatment technologies, and only a relatively low number of households as connected to sewerage systems, with wastewater treatment plants that have varied ownerships. Therefore, the amount of GHG emissions, in CO2 equivalent, that are attributable to NWSDB is likely relatively small, although this is something that may need to be studied more (and perhaps sector wide rather than with a focus on NWSDB) given the planned investments included in the sanitation master plan (see below).

26. Some data sources from the sanitation master plan may be combined with rules of thumb from literature to arrive at a preliminary ballpark figure for GHG emissions from wastewater treatment plants owned by NWSDB. See Table 2.

Table 2. NWSDB Wastewater Treatment Plants.

Wastewater treatment plant	Treated effluent (m^3/day)
Ratmalana	17,200
Ekala	7,200
Kandy	14,000
Kurunegala	4,200
Total	**42,600**

Source: NWSDB (undated), Sanitation Master Plan (2021-2030).

27. Noting the total wastewater treatment volume of 42,600 m^3/day and applying the rule of thumb of 1.8 kgCO2e emissions per m^3 treated (combined CO2, CH4 and N2O), annual CH4 and N2O emissions from wastewater treatment can be estimated as 27,988 tCO2e/year. However, this figure is subject to considerable uncertainty depending on technology, pollutant loads, capture and utilization of biogas, etc.

[20] EB (2022), Methodological Tool: Default values for common parameters. Tool 33 of the Clean Development Mechanism. Version 2.0, dated 8 September 2022. Executive Board for the Clean Development Mechanism. https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-33-v2.0.pdf
See Table 1. The value used (0.8 tCO2/MWh) is consistent with a load factor below 25% and generator capacity in excess of 200kW (responsible for most of the diesel use for power generation).

28. The sanitation master plan foresees in a gradual increase in the percentage of households that are connected to sewerage systems and a fast expansion of the number of households that benefit from improved onsite sanitation combined with fecal sludge management, which is summarized in Table 3 and includes 50 new fecal sludge treatment plants and 15 rehabilitated fecal sludge treatment plants as NWSDB contributions. Moreover, the sanitation master plan foresees a rapid increase in the number of decentralized wastewater treatment plants (DEWATS). It is important to understand technological and design choices as these may have a significant impact on GHG emissions, c.q. offer significant GHG mitigation options vis-à-vis business-as-usual.

Table 3. Coverage plan, Sanitation Master Plan.

Year Sanitation option	2020	2025	2030
Connected to sewer networks	2.1%	3.0%	4.4%
Access to onsite sanitation	91.5%	94.3%	95.6%
Total Basic Sanitation coverage	***93.6%***	***97.3%***	***100.0%***
Improved onsite sanitation + Fecal Sludge Management	9.0%	38.0%	53.0%
Total Safe Sanitation coverage	***11.1%***	***41.0%***	***57.4%***

Source: NWSDB (undated), Sanitation Master Plan (2021-2030).

29. The bulk of the GHG emissions (177,013 tCO2/year, 82.33% of the total) are due to consumption of power supplied by the grid. The estimate is obtained through multiplication of the amount of power consumed by the grid emission factor, which is the grid emission factor for electricity consumption jointly agreed to by IFIs including ADB.

Table 4. Breakdown of power consumption.

Power use	Amount consumed (MWh/year)	Percentage of total
Pumping	340,464	97.30%
Buildings	5,830	1.67%
Sewerage	3,634	1.04%
Total	**349,928**	**100.00%**

Source: Data from NWSDB, calculations from the author.

30. Table 4 shows the breakdown of power consumption. It is clear that pumping dominates energy use and hence is responsible for the bulk of the GHG emissions due to power consumption, while both sewerage and buildings only contribute relatively small amounts.

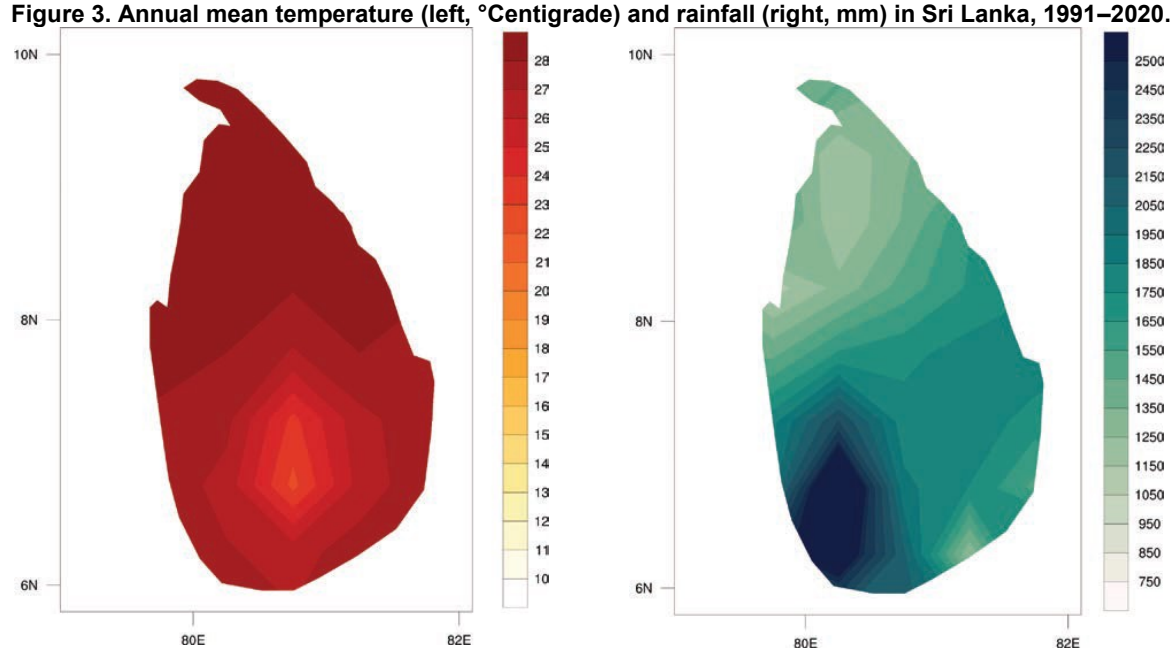
IV. CLIMATE CHANGE RISKS TO WHICH NWSDB IS EXPOSED

31. To identify the climate change risks and vulnerabilities to which NWSDB is exposed, a variety of approaches were followed. In part, we summarized the information available in official documents prepared under the UNFCCC, such as the Third National Communication of Sri Lanka and the updated Nationally Determined Contribution of Sri Lanka. This was combined with information on water sector (adaptation) NDC responsibilities that have been primarily allocated to NWSDB, risk maps prepared by Disaster Management Centre[21] (DMC), and a sample of water supply schemes with more detailed information on building locations and operational assets, and information collected during a visit to NWSDB, such as the Sanitation Master Plan. On the basis of this information, an initial assessment could be prepared of the climate change risks to which NWSDB is exposed.

A. Summary of findings from official reports submitted under the UNFCCC

32. Sri Lanka is a small island nation lying between 6°N and 10°N latitude and 80°E and 82°E longitude in the Indian Ocean, with a land area of approximately 65,000 square kilometers (km2). The island consists of a mountainous area in the south-central region and a surrounding coastal plain. The climate of Sri Lanka is wet and warm, ideal for forest growth; almost all of the nation's land area was at one time covered with forests[22].

Figure 3. Annual mean temperature (left, °Centigrade) and rainfall (right, mm) in Sri Lanka, 1991–2020.



Source: ADB and World Bank. 2021. Climate Risk Country Profile: Sri Lanka. p.6.

33. Sri Lanka has two main seasons, the Maha season associated with the northeast monsoon (September–March) and the Yala season associated with the southwest monsoon (May–August). With an average temperature of around 27°C–28°C, Sri Lanka is one of the hottest countries in the world. Sri Lanka's commercial capital, Colombo, experiences average temperatures of 28°C–29°C and, like much of the rest of the country, has little monthly variation in temperature. Daily maximum temperatures average around 31°C all year round. The most important factor affecting temperature variations within Sri Lanka is

[21] Disaster Management Centre. 2019. Risk Index for Sri Lanka. (Population risk for Flood, Drought (Drinking Water Scarcity), Landslides & Tsunami).
[22] ADB and World Bank. 2021. Climate Risk Country Profile: Sri Lanka. p.2.

altitude, with considerably lower temperatures experienced in its south-central mountain ranges[23].

34. Sri Lanka's topography creates unique rainfall patterns, with notable spatial variation for a country of its size. Sri Lanka's precipitation regime is divided into three zones: the wet zone, intermediate zone, and dry zone. The wet zone, found in the southwest, receives a mean annual rainfall of over 2,500 millimeters (mm), with a strong contribution from the southwest monsoon. The dry zones, found in the south and northwest, receive less than 1,750 mm. The intermediate zones found in the eastern and central regions, receive between 1,750 mm and 2,500 mm, primarily from the northeast monsoon. Areas of the southwestern slopes of the central hills are known to experience as much as 5,000 mm in a year and annual rainfall can vary by more than 1,000–2,000 mm over distances of less than 100 km. All regions receive steady rainfall during the inter-monsoon seasons. Figure 3 shows the spatial distribution of observed mean annual temperature and rainfall across Sri Lanka[24].

35. As both the TNC and the updated NDC note, Sri Lanka ranks among the countries that are most vulnerable to climate change-induced hazards. A tropical island in the Indian Ocean, Sri Lanka has consistently been placed among the top ten countries in terms of climate vulnerability.

36. The most frequent natural hazards that impact Sri Lanka are droughts, floods, landslides, cyclones, and coastal erosion. A rise in extreme events and disasters triggered by natural hazards as a result of climate change is expected to pose considerable threat to Sri Lanka's economy and human health.[25] To this can be added that Sri Lanka faces significant threat from extreme heat, with the number of days surpassing 35°C, potentially rising from a baseline of 20 days to more than 100 days by the 2090s, under emissions pathway RCP8.5. Extreme heat threatens human health and living standards[26].

37. The Global Climate Risk Index published by Germanwatch[27] has ranked the country as the 4th in 2018, 2nd 2019 and 6th in 2020 in the list of countries most vulnerable to climate change, with an average annual loss of US$ 2,129 million due to climate change. The World Bank estimates that 7.7 percent (US$ 50 billion) of GDP, needs to be allocated to face disasters triggered by climate change by 2050[28]. Sectors that contribute significantly to Sri Lanka's economy tourism, fisheries, tea plantations and agriculture are climate-sensitive and impacted by the disruption of monsoons and altered rainfall.

38. According to the TNC, average temperature in Sri Lanka could rise by 2.3°C - 3.6°C by 2080, depending on the scenario. Predicted rainfall change shows anomalies, without a clear direction. However, the intensity and frequency of extreme events relating to rainfall (e.g. heavy rainfall events and total absence of rainfall over lengthy spells) are increasing and such extreme events are directly linked to hazards such as floods, landslides and droughts.

39. In the updated NDC adaptation measures related to domestic water and some of the NDC adaptation measures related to urban planning and human settlements are relevant to

[23] ADB and World Bank. 2021. Climate Risk Country Profile: Sri Lanka. p.5.
[24] ADB and World Bank. 2021. Climate Risk Country Profile: Sri Lanka. p.5.
[25] https://climateknowledgeportal.worldbank.org/country/sri-lanka/vulnerability
[26] ADB and World Bank. 2021. Climate Risk Country Profile: Sri Lanka. P.2.
[27] https://www.germanwatch.org/en/cri
[28] Ministry of Environment. 2022. Third National Communication of Climate Change in Sri Lanka. Submission to the UNFCCC Secretariat prepared by the Climate Change Secretariat, Ministry of Environment. p.xx.

this assignment. These NDC adaptation measures, including their sub-measures, are presented in the text below.

40. In domestic water supply, five adaptation measures have been identified in the NDC, presented below together with the identified sub-measures.

1) Ground and surface water monitoring in the Northern, North Central and North Western provinces and other areas of high drinking water vulnerability to drought.
   - Conduct risk assessments and contingency plans for all new drinking water projects in priority areas.
   - Seek new water sources and options (i.e. rainwater harvesting and sub surface water) to augment water supply in areas where supply is scarce.
   - Mitigation of drought impact by establishing provisional deep wells on risk-prone districts.
   - Identify and implement appropriate groundwater recharge systems of the water deficit areas.
   - Ensure water security at all times with the required quality and quantity of water.
   - Establish sustainable extraction levels of ground water in at least three river basins (by 2025).and expand coverage by further three river basins.
2) Promote climate-resilient water supply schemes.
   - Establish new technology in real- time measurements of water quality and level on major water sources in a collaborative manner with water sector institutions.
   - Devise mechanisms to supply safe drinking water during floods, droughts and during saltwater intrusion for all water supply schemes vulnerable to floods, droughts and saltwater intrusion.
   - Strengthen interagency coordination for early warning on climate and weather-related disasters and health emergencies with timely disaster response.
   - Innovative approaches such as Payment for Ecosystem Services (PES) to be explored for catchment protection in vulnerable regions.
   - Establish desalination or rainwater facilities in most vulnerable areas with inadequate other sources of potable water.
   - Minimize the level of non-revenue Water (NRW) as a water conservation / efficiency improvement measure in all water supply schemes.
3) Promote the use of wastewater for gardening, sanitary, construction and other purposes to reduce demand for treated water.
   - Some policy initiatives at the national level for use of treated water for other purposes piloting in industries, industrial parks and apartment buildings.
   - Promotion of most appropriate mechanisms of water conservation / reusing / recycling for different purposes.
   - Introduce by-laws and building codes to introduce reuse of wastewater in new industrial constructions including areas under industrial estates.
   - Introduce market mechanisms for promoting above.
   - Public awareness-raising on private and social benefits of wastewater management.
4) Establish salinity barriers in 3 rivers where intakes are subjected to climate change influenced saline water intrusion during the drought season (covering Kelani Ganga, Kalu Ganga, and Malwathu Oya).
   - Identify best solutions (covering technical and financial) for salinity barriers for each case.
   - Establish salinity barriers at each critical river identified.
   - Assess and establish regulatory mechanisms to manage ground water extraction in areas with salinity intrusion issue.
   - Monitoring and recording of saline water intrusion into drinking water sources especially during drought periods.

- Strengthening interagency coordination in early warning of salinity intrusion and allocation of water for flushing as a priority when needed.

5) Capacity building for water sector personnel and public awareness on building resilience to climate change.
   - Capacity needs assessment of the water sector institutions and the personnel on climate resilience building.
   - Prepare plans for building capacity in each institution to effectively implement the sector NDCs including that of community water supply schemes.
   - Awareness raising and behavioral change campaigns for the public towards sustainable use of water as a climate resilience building for water security.
   - Capacity development in communities and Community Based Organizations in addressing climate resilience in water resources.
   - Demand-Side Management and promotion of 3R amongst water users in most vulnerable areas for climate change.
   - Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities.
   - Supply-Side Management through enhanced efficiency in abstraction, transmission, and distribution of drinking water.

41. In urban planning and human settlements, some of the proposed adaptation measures may be relevant for protecting buildings and other assets. Therefore, most of the measures proposed in the updated NDC have been listed below, with the exception of a measure related to planning, which focuses on planning authorities.

1) Incorporate Disaster Risk Reduction into the urban and human settlement planning / implementation in areas of high vulnerability to climate change risks.
   - Develop Guidelines on Climate Change influenced Disaster Risk Management for urban and human settlement planning.
   - Design and maintain infrastructure giving due consideration to the runoff system/drainage and flooding.
   - Incorporate slope stability and soil conservation measures in developing infrastructure in hilly areas.
   - Assess landslide / flood risk to human settlement and infrastructure and introduce measures to reduce the vulnerability in high-risk areas.
   - Assess drought risk to human settlement and introduce measures to reduce vulnerability in high-risk areas.
2) Establish a climate-resilient built environment.
   - Integrate climate risk projections into climate-resilient built environment strategies implemented by respective stakeholder institutions.
   - Review and update climate-resilient design strategies to address emerging climate risks.
   - Amend and gazette existing human settlement plans to integrate climate-resilient strategies.
   - Review, update and enforce existing rules and regulations to prevent built environments in areas highly vulnerable to climate change.
   - Include sustainable built environment concepts into Architecture and Engineering curricular.
   - Promote vertical housing solutions, where appropriate to communities living in high climate risk areas.
3) Minimize the impact of slow onset events (sea-level rise) on coastal settlements and infrastructure.
   - Design coastal settlements and associated infrastructure considering future sea-level rise.

- Demarcate protection areas from sea level rise to facilitate for shifting urban densification inward.
- Prepare and commence implementation of risk management plans for existing coastal infrastructure and settlements.

B. Water sector adaptation NDC responsibilities allocated to NWSDB

42. During the visit to NWSDB in September, an overview was prepared of the NDC measures related to adaptation in the water sector to which NWSDB has been allocated the primary responsibility. Below we provide an overview of these measures for which NWSDB is primarily responsible, which is relevant because investments related to these responsibilities would need to be reflected into the proposed adaptation investment measures. It should be emphasized that implementation of these NWSDB measures is ongoing, and that it has not been possible to comprehensively assess for which of these NDC measures additional investments and financing are needed.

Table 5. NDC water sector adaptation measures for which NWSDB is lead agency

NDC measures for which NWSDB is lead agency	Other agencies involved	Progress
NDC 1 - Integrated River Basin Management (IRBM) approach adopted in 15 prioritized river basins in Sri Lanka		
No measures led by NWSDB		
NDC 2 - Ground and surface water monitoring in the Northern, North Central and North Western provinces and other areas of high drinking water vulnerability to drought		
2.1.1 New drinking water projects	MoWS, WRB, LA, CEA, DoI, DNCWS, MASL	• In 2021: Additional 15 (total 33) • In 2022: 36 • In 2023: 19
2.2.1 Seek new water sources and options – Surface and sub - surface water	WRB, DNCWS, DAD, ID, DoA, MASL, Plantation Sector Co,	• In 2022: Four WSS (Glenore, Mankulam, (Lunuwatta & Musali WSSs) • In 2023 Lahugala WSS up to July
2.5 Ensure water security at all times with the required quality and quantity of water	WRB, DNCWS, DCS, DS, NGOs, CBOs, LAs, DS	Among others • In 2022: bacteriology satisfied 98.07%; physical satisfactory 90.87% • In 2023: bacteriology satisfied 98.40%; physical satisfactory 92.46%
NDC 3 - Promote climate-resilient water supply schemes		
No measures led by NWSDB		
NDC 4 - Promote the use of wastewater for gardening, sanitary, construction and other purposes to reduce demand for treated water		
4.2.1 Implement regulatory measures for water fittings	SLSI, MoWS,	In 2021 and 2022: • Categories identified, regulations to be developed. • Design contract awarded in 2022 and in-progress. Construction contract will be awarded by NWSDB in 2023.
NDC 5 - Establish salinity barriers in 03 rivers where intakes are subjected to climate change influenced saline water intrusion during the drought season (covering Kelani Ganga, Kalu Ganga, and Malwathu Oya)		
5.1 Identify best solutions (covering technical and financial) for salinity barriers for each case	ID, IWMI, CEA, LHI, Academia	1. Salinity barriers with best solutions: In 2021 and 2022: Work in progress (Studies ongoing for Ambthale)

NDC measures for which NWSDB is lead agency	Other agencies involved	Progress
		Remarks: Best solutions for salinity barriers at Gin Ganga, Walawe ganga, Nilwala ganga, Kelani Ganga and Kalu ganga were identified before 2020, but completed for 3 in 2020. 2. Feasibility studies: In 2021 and 2022: • Feasibility study of Ambathale salinity barrier is in progress. • Studies have been planned for salinity barriers at Kalu ganga
5.2 Establish salinity barriers at each critical river identified	ID, CEA, Academia	In 2021 and 2022: • Constructions of the salinity Barrier at Nilwala Ganga is ongoing. • Plans have been developed for salinity barriers at Kalu Ganga and Kelani Ganga
5.4 Monitoring and recording of saline water intrusion into drinking water sources especially during drought periods	MoWS, WRB, DNCWS, Academia	In 2021 and 2022: Daily reports Remarks: Real time water Quality monitoring report and NWSDB laboratory Water quality report Water quality records on Salinity Intrusion in three river basins
NDC 6 - Capacity building for water sector personnel and public awareness on building resilience to climate change		
6.2 Prepare plans for building capacity in each institution to effectively implement the sector NDCs including that of community water supply schemes (lead agency together with MoWS and CCS)	MoWS, DNCWS, CCS, IWMI, UNDP, UNICEFF, DNCWS, DoA, LAs, DAD, Academia, SLRWHF, NGOs	In 2021 and 2022: Monitoring and evaluation system not initiated due to lack of funds. No specific training on NDC conducted.
6.3 Awareness raising and behavioral change campaigns for the public towards sustainable use of water as a climate resilience building for water security (lead agency together with MoWS)	DNCWS, ID, MASL, NGOs, UNICEFF, UNDP, Research Org, GWP, NGOs, CBOs	In 2021 and 2022: NWSDB – 49 in 2021 and none in 2022 Remarks: Street drama to be developed related to CR Impact/ public consultation meetings
6.6 Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities	CIDA, VTA	• In 2021: Continues • In 2022: Accreditation scheme finalized Remarks: In CIDA, discussion on licensing for plumbers ongoing
NDC 7 - Restore, rehabilitate and augment 25 major /medium reservoirs and 300 minor irrigation systems and 200 km length of irrigation canals of Sri Lanka for enhancing climate resilience in the agriculture sector		
7.4.1 Construction of upstream reservoirs for drinking water	MoWS, MoI	In 2021 and 2022: • Feasibility studies on augmentation

NDC measures for which NWSDB is lead agency	Other agencies involved	Progress
		done; • Yatimahana tank built In 2023: • EIA study for Proposed Yatimahana Reservoir is on going
NDC 8 - Introduce or promote alternative water resources as a climate change resilience building intervention for domestic and supplementary irrigation		
No measures led by NWSDB		
NDC 9 - Enhance water management in 40 irrigation schemes		
No measures led by NWSDB		
NDC 10 - Assess river floods and mitigation measures and early warning systems for possible flash floods for five priority basins (covering Kelani Ganga, Attanagalu Oya, Kalu Ganga, Kirindi Oya and Malwathu Oya on pilot basis)		
No measures led by NWSDB		

Source: Extracted by the author from information provided by NWSDB

C. Review of risk maps

43. For elected risks (flood, drought, landslide, tsunami), DMC has prepared risk index maps[29], country wide and at the level of the various districts. The country-wide are presented in the figures below and these maps can provide an indication of where and to what risks NWSDB assets and operations may be exposed. This goes beyond the analysis of the risks on the basis of the moderate sample (see the next subsection).

44. shows the flood risk map of Sri Lanka. It is clear that flood risk has a distinct distribution over the country, with high levels of flood risk in the North (Jaffna District, Kilinochchi District, Mullativu District), Northwest (Mannar District), Southwest (Colombo District, Gampaha District, Kalutara District), South (Galle District, Matara District), and East (Polonnaruwa District, Trincomalee District) of Sri Lanka. NWSDB assets and operations located in these districts will need to be screened for potential flood risks, and where considerable flood risks exist, protective measures need to be taken. For future assets and operations in these districts, location decisions need to take flood risks into account, and if location away from the main flood risks is not a viable option, appropriate adaptation measures need to be included.

[29] The risk index has been calculated according to the formula Risk = Hazard x (Vulnerability/ Capacity). Hazard maps were not available in the documentation consulted.

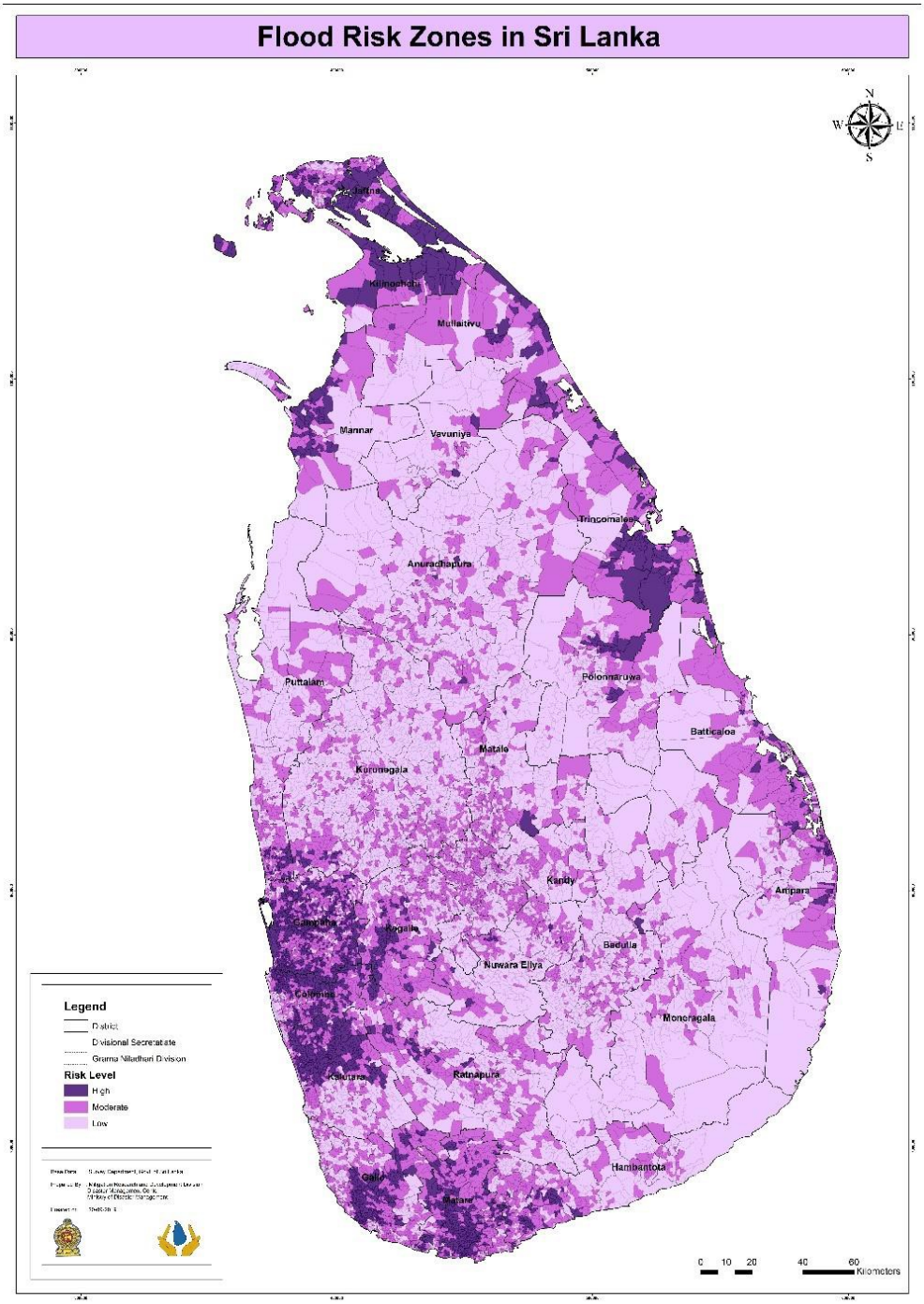


Figure 4. Flood risk map of Sri Lanka.

Source: Disaster Management Centre. 2019. Risk Index for Sri Lanka. (Population risk for Flood, Drought (Drinking Water Scarcity), Landslides & Tsunami), p.8.

45. Drought risk () is more spread out over Sri Lanka than flood risk. Districts that are particular susceptible to drought risks include Jaffna District, Kilinochchi District, Mullativu District, Gampaha District, Kalutara District, Kegalle District, Matale District, Trincomalee District, Ampara District, Batticaloa District, Hambantota District, and Puttalam District.

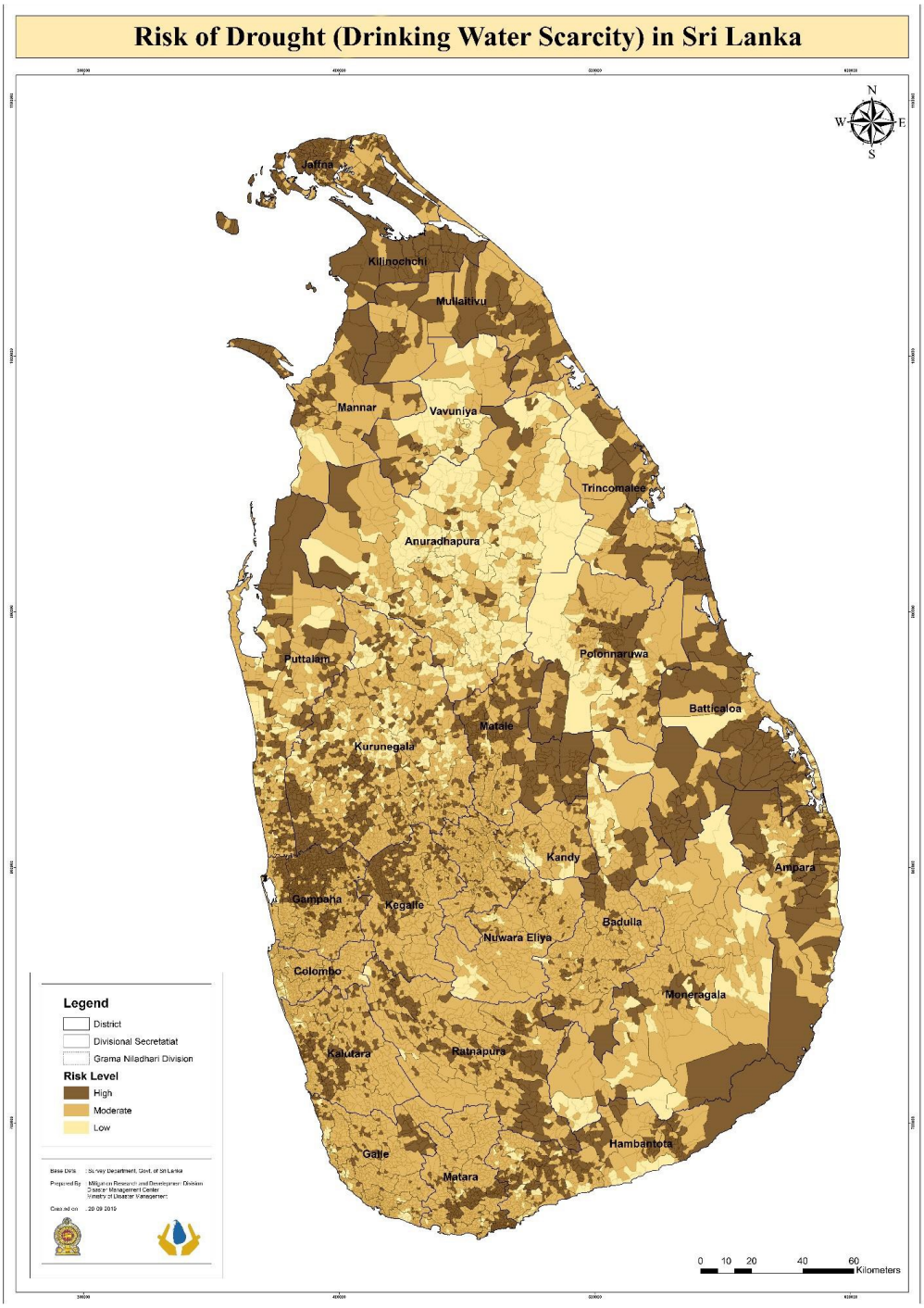


Figure 5. Drought risk map of Sri Lanka.

Source: Disaster Management Centre. 2019. Risk Index for Sri Lanka. (Population risk for Flood, Drought (Drinking Water Scarcity), Landslides & Tsunami), p.8.

46. Landslide risks are reflected in . It should be noted that for the northern parts of Sri Lanka, data are missing so that the maps do not reflect landslide risks in those regions. The main areas where landslide risks have been identified are in the central and southwestern parts of Sri Lanka, in particular in Kalutara District, Kandy District, Kegalle District, Matale District, Nuwara Eliya District, Ratnapura District, and to a lesser extent, Badulla District and Galle District.

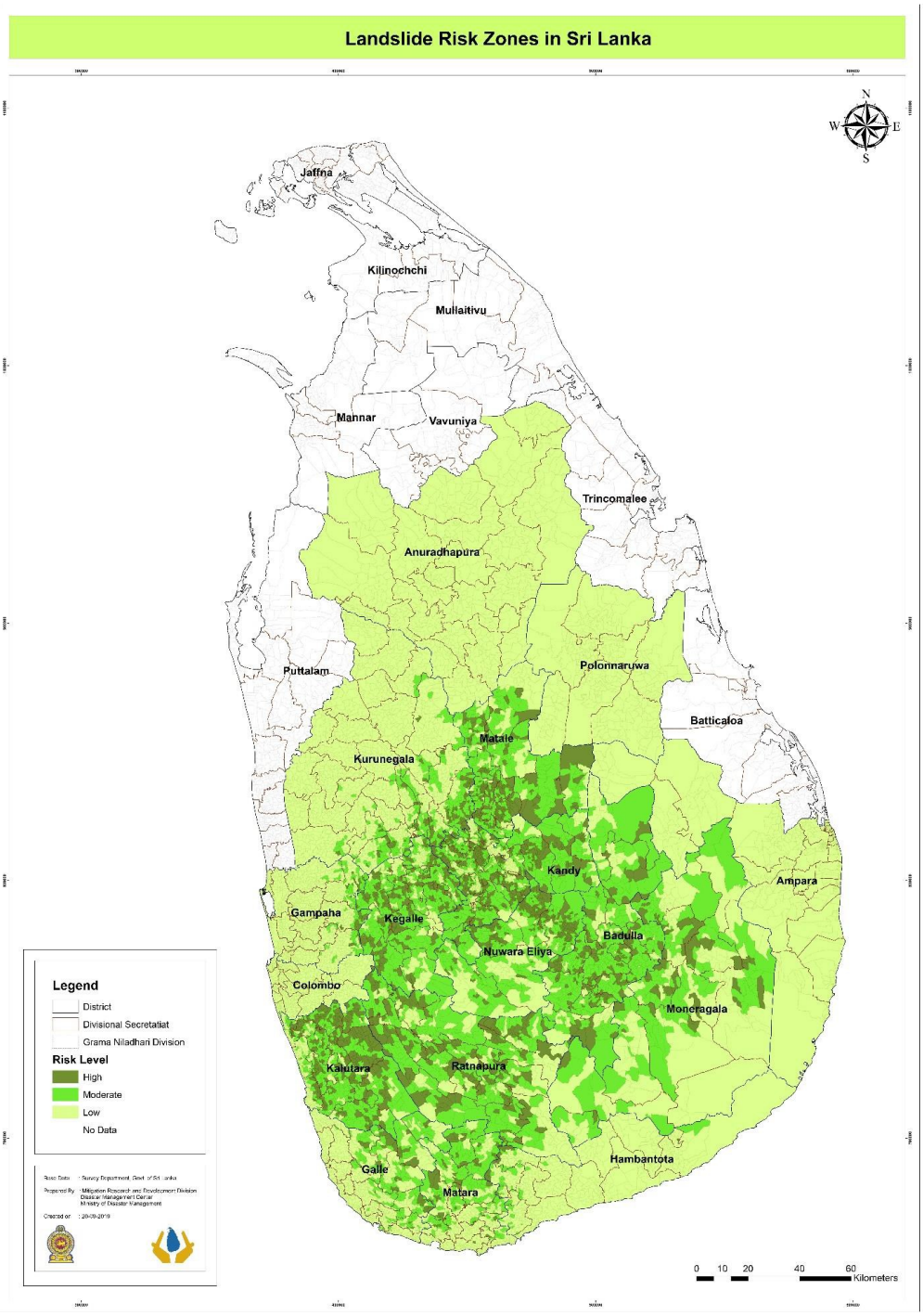


Figure 6. Landslide risk map of Sri Lanka

Source: Disaster Management Centre. 2019. Risk Index for Sri Lanka. (Population risk for Flood, Drought (Drinking Water Scarcity), Landslides & Tsunami), p.9.

47. Finally, and unsurprisingly, tsunami risks () are concentrated in the coastal districts, strictly along the coasts.

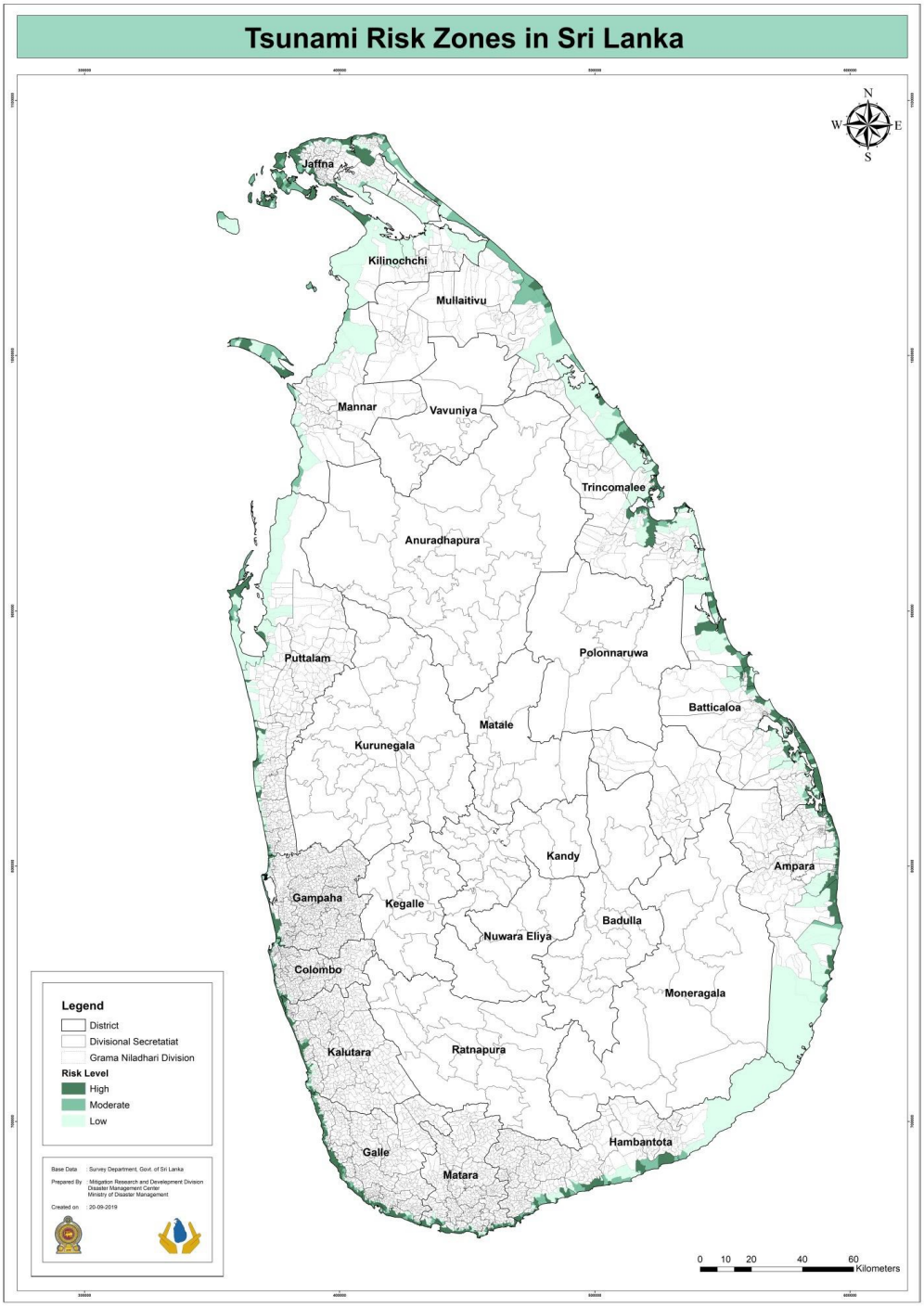


Figure 7. Tsunami risk map of Sri Lanka

Source: Disaster Management Centre. 2019. Risk Index for Sri Lanka. (Population risk for Flood, Drought (Drinking Water Scarcity), Landslides & Tsunami), p.9.

48. No risk map exists for saltwater intrusion, however, based on information about NDCs and salinity barriers (constructed and planned), saltwater intrusion is concentrated where the following rivers drain into the sea: Kelani Ganga (Colombo District), Kalu Ganga (Kalutara District), Malwathu Oya (Mannar), Gin Ganga (Galle), Walawe Ganga (Hambantota) and Nilwala Ganga (Matara).

49. The information in the risk index maps was also combined with information gathered from the sample of RSCs and WSSs. In Table 6, this report has summarized the information related to the risks sampled NWSDB buildings are exposed to.

Table 6. Risk exposure of sampled NWSDB buildings

Degree of risk	Flood	Drought	Landslide	Tsunami
High	17%	14%	0%	11%
Moderate	22%	19%	36%	3%
Low	61%	67%	64%	3%
No risk				83%
Number of observations	*36*	*36*	*25*	*36*

Source: Author combining information from the DMC risk indices with information on sampled buildings.

D. Heat, sanitation and health

50. As noted, Sri Lanka has a very hot climate, and climate change has caused and is causing further temperature increases. This makes proper sanitation more important. Most of the Sri Lankan population uses on-site sanitation (OSS), which means that toilet waste is stored near its origin in below-ground storage tanks. This comes with potential drawbacks, and it is worthwhile to quote an IWMI blog on this subject[30]:

> "*The main disadvantage of OSS is that if not maintained properly, it does not work and can cause harm to public health and the aqueous environment through uncontrolled discharge of contaminated wastewater.*
>
> *In rural Sri Lanka improved latrines are common. Some locally, brick-made tanks don't match the mandatory dimensions stipulated by Sri Lankan Standards (SLS). They might be cheaper, but they can fill-up too quickly, or leak. While some tanks are so well-constructed that they take many years to fill, others require a service every other year.*
>
> *Some tanks with multiple chambers allow the liquid part of the wastewater to leave the system via a soakaway or final soakage pit, while the solid parts of the wastewater is separated and stored. If the solids at the bottom fill up, the soakaway can be blocked and wastewater will eventually cause the lid to lift and thus overflow. This often leads to a bad smell, and potential health and environmental hazards.*
>
> *What happens when the tank is full?*
>
> *Emptying the sludge is done by special collection services ('gully-bowsers') which suck the sludge out of the tanks. These services exist in nearly all communities and are operated by both private and public service providers. There are two big challenges:*
> 1) *How do you know when your tank is getting full? Many families rent houses and don't know where the tanks are, or when they were last emptied. The tank lids are often sealed or hidden under grass. As a result, many tanks are only emptied once they have burst.*
> 2) *The number of treatment plants and the number of trucks emptying septic tanks don't match up. Ideally, there should be designated treatment plants in close vicinity to communities (also to ensure the gulley-browsers have a short turn-around time) where the sludge is safely treated. This is currently not the case. There are so far*

[30] https://www.iwmi.cgiar.org/2020/11/modernizing-wastewater-treatment-in-sri-lanka/

only 20+ fecal sludge treatment plants in the country, and many are too far away (and thus expensive) for a gully-browser to use, which can result in illegal sludge dumping. In the Colombo area, most sludge is discharged into the sewer system, which leads to ocean contamination.

The existing treatment plants

As part of a World Bank assessment of the present fecal sludge management (FSM) situation in Sri Lanka, IWMI researchers visited all the country's treatment plants. Small or large, simple or complex, all treatment plants use similar primary (grit removal, sedimentation) and secondary (oxidation or anaerobic digestion) treatment stages. Whereas a number of treatment plants visited are under-dimensioned and overloaded, others are too large and only a fraction of their treatment capacities are utilized.

The good news is that most of the treatment plants operating in Sri Lanka are functioning and resources such as nutrients and organic matter are recovered and recycled (mostly as organic fertilizer). Liquid effluent is discharged after treatment into nearby wetlands, rivers or drains."

51. Climate change increases the disadvantages of the current system and the resulting challenges to public health. This point is addressed in the sanitation master plan, in which NWSDB plays an important role.

52. Based on the above sections, Table 7 summarizes the main identified risks and vulnerabilities related to climate change as it affects NWSDB. Note that wind did not appear to be a major risk for NWSDB. Should this assessment be incorrect, the table below would need to be expanded and additional adaptation measures could be considered, such as use of bracing technologies to stabilize buildings, use of windbreaks, etc.

Table 7. Summary of NWSDB climate-related challenges

Climate hazard	Primarily affected NWSDB assets / operations / services	Impacts
Increased temperatures	• Wastewater management; • Small-scale sanitation systems (OSS) requiring NWSDB servicing (fecal sludge management)	1) Increased risk to health through increased spread of pathogens
	Water storage	2) Increased evaporative losses from water source
	Water extraction and conveyance, Water treatment, Water storage and distribution	3) Increased demand for water may put stress on the NWSDB supply system
Sea level rise	• Water extraction and conveyance; • Water treatment	4) Increased saltwater intrusion 5) Lower quality water resources due to increased salinity requiring more and more costly treatment 6) Increased risk to health
Increase in precipitation or increased frequency of extreme precipitation events and storm Surges	• Water extraction and conveyance, Water treatment, Wastewater treatment, Water storage and distribution • Small-scale sanitation systems (OSS) requiring NWSDB servicing (fecal sludge management)	7) Increased risk of flooding resulting in damage to NWSDB operations and assets. 8) Increased risk of damage due to flooding and/or landslides 9) Increased risk of rising water tables exposing underground structures to ground movements and flotation, which

Climate hazard	Primarily affected NWSDB assets / operations / services	Impacts
	• NWSDB buildings	could cause structural damage and inundation; increased risk of septic tanks and pit latrines flooding or filling with silt. 10) Increased risk to health through increased spread of pathogens 11) Danger to users of NWSDB buildings resulting from flooding and/or landslides 12) Intake blockages due to silt and floating objects 13) Inaccessibility to operators of NWSDB Intakes / buildings resulting from flooding. 14) Additional treatment costs due to poor source water quality 15) Power failures due to extreme weather 16) Increased risk of source water quality depletion resulting plant shutdown and revenue loss 17) Interruption of source water extraction due to dislocation of floating intakes
Droughts	Water extraction and conveyance, Water treatment, Water storage and distribution	18) Increased risk to temporary shortages of water in drought periods. 19) Decrease in surface and groundwater availability 20) Water scarcity 21) Increased water demand 22) Increased competition with other water users 23) Water quality deterioration due to low dilution and algae proliferation. 24) Additional cost for water treatment, increased pumping and bowser supply 25) Increased saltwater intrusion due to low flow in rivers 26) Difficulty of source water extraction using floating intakes 27) Diversion of flow of rivers from direct intake locations 28) Low pressure in distribution systems due to increased water consumptions

Source: Preceding sections consolidated by the author; comments and experience from NWSDB

53. It should be noted that some of these hazards can reinforce each other and hence increase the need for effective action. For example, droughts may increase the threat from salinity intrusion.

V. POTENTIAL AND PROPOSED MITIGATION OPTIONS

A. Potential mitigation options

54. Based on the analysis in Section III, the main confirmed sources of GHG emissions are consumption of power supplied by the grid, use of fuels for vehicles and mobile equipment, use of diesel by generators, and potentially GHG emissions from wastewater treatment plants owned by NWSDB (subject to significant uncertainty). Based on these, the potential mitigation options presented in Table 8 have been formulated. This table provides the longlist of mitigation options considered. The paragraphs following the table comment on each of these options in turn, explaining the mitigation potential calculation and why each option is or is not included in the proposed / recommended list of mitigation options.

Table 8. Longlist of potential mitigation options.

Source of emissions	Mitigation option	Mitigation potential (tCO2/year; stand-alone)[31]
Diesel for vehicles	1. Switch to biodiesel	27,746
	2. Switch to electric vehicles	13,965
Gasoline for vehicles	3. Switch to electric vehicles	258
Diesel for power generation	4. Switch to biodiesel	5,756
	5. Switch to solar PV	6,396
GHG emissions from wastewater treatment	6. Switch from anaerobic to aerobic systems	More information needed
	7. Methane capture and utilization	More information needed
	8. Methane avoidance	More information needed
	9. Composting	More information needed
Consumption of power supplied by the grid	10. Reduction of technical water losses	11,593
	11. Use of gravity flow	Assumed all possibilities used, hence 0.
	12. Increased pumping efficiency	42,156
	13. Solar PV investment	31,540
	14. Renewable energy other than solar	More information needed

Source: Author's analysis and calculations

55. The **first option** replaces diesel with biodiesel, which is a close to zero emissions fuel. Because biodiesel requires some energy during its production process and energy for the transport of the feedstock, it is not quite a zero emission source, and hence emission reductions have been estimated as 90% of the baseline emissions.

56. The main difficulty with the first option is the availability of biodiesel – unless it can be bought in the market from an existing producer (unlikely), the production process of biodiesel is quite involved, requiring either the sourcing of waste feedstocks (e.g. fat from slaughterhouses) or growing of oil crops that will need to be processed. In either case, follow up chemical reactions are needed. It is unlikely that NWSDB would like to involve itself in

[31] This column assumes that each mitigation option is implemented standalone, without the other being implemented. For example, a measure to increase pumping energy efficiency will have a different mitigation impact when it is implemented in combination with a solar PV project that partially replaces grid-based power consumption with solar PV then when it is implemented without such parallel investment.

this, as it is markedly distant from its core business, and it is also unlikely that other producers exist from which biodiesel can be sourced.

57. In the future, should biodiesel become widely available in Sri Lanka, NWSDB may have the potential to use it. It should be noted that NWSDB has vehicles with different types of engines and generators, and therefore will need to consider the impact of switching from diesel to biodiesel for present engines. It may be worthwhile to conduct a study on the suitability of biodiesel NWSDB diesel engines.

58. The **second option**, switch to electric vehicles to reduce diesel-related emissions produces emission reductions of about 45.3% of the baseline emissions assuming that the electric vehicle uses grid power to charge the batteries. Over time, the amount of renewable power on the grid will increase, and the reduction percentage will increase as a result; this effect has not been included in the projections which hence may underestimate true emission reduction potentials.

59. Whether or not NWSDB wishes to implement this option is a question of 1) costs (no data have been gathered on the costs of electric vehicles in Sri Lanka and on fuel prices, so no analysis has been made); 2) existence of sufficient charging infrastructure; and 3) availability of vehicles with the right characteristics.

60. In NWSDB's experience, as NWSDB vehicles are more used than private vehicles in general, it is in dire need of spare parts. Availability of spare parts across the country is a must. Other than that, having to use public charging points can also be problematic and it shall be considered charging time. Also, considering the energy loss during energy conversion, it should be considered whether it is also advantageous to use electricity generated using fossil fuel.

61. The **third option**, switch to electric vehicles to reduce gasoline related emissions produces emission reductions of about 34.2% of the baseline emissions assuming that the electric vehicle uses grid power to charge the batteries. The reduction percentage is lower than in case of replacement of diesel-power vehicles, because gasoline is a less GHG-intensive fuel than diesel. Over time, the amount of renewable power on the grid will increase, and the reduction percentage will increase as a result; this effect has not been included in the projections which hence may underestimate true emission reduction potentials.

62. Whether or not NWSDB wishes to implement this option is a question of 1) costs (no data have been gathered on the costs of electric vehicles in Sri Lanka and on fuel prices, so no analysis has been made); 2) existence of sufficient charging infrastructure; and 3) availability of vehicles with the right characteristics. In any case, given the limited amount of emissions from gasoline-fueled vehicles, it would make sense to either support a switch to electric vehicles for bother gasoline- and diesel-fueled vehicles, or not to implement such a switch at all.

63. The **fourth option**, switch to biodiesel to replace diesel-use in generators, is similar to the first option. Emission reductions are estimated as 90% of the baseline emissions. The main problem is the same as with the first option: the availability of biodiesel, which is unlikely.

64. The **fifth option**, switch to solar power replace decentralized power produced from diesel results in the use of a zero-emissions power source. Hence the emission reductions are equal to the baseline emissions. There are no obstacles to this investment, which likely will have a reasonable internal rate of return and is in line with plans submitted by NWSDB

(see below). These plans exceed what is needed to replace power from the generators, and hence the larger PV investment option is chosen for inclusion in the list of proposed mitigation investments.

65. The **sixth, seventh, eighth and ninth option** all require further study. More information needs to be obtained about the wastewater treatment subsector as it currently exists (including onsite sanitation and fecal sludge treatment plans) and the plans as formulated in the sanitation master plan, to understand current emissions, emissions related to future plans, and options to mitigate GHG emissions from the subsector. This can include a wide variety of options, which may result in several byproducts, including energy, natural fertilizer, and water suitable for irrigation and other purposes. For example, technologies exist to anaerobically digest wastewater to produce biogas, which can be used for cooking and/or power generation; to anaerobically digest fecal sludge and incinerate the digestate for power generation, or alternatively use the digestate as natural fertilizer; or to clean wastewater with duckweed to produce a combination of clean water (up to drinking water quality with further processing, alternatively, for irrigation purposes), food (shrimps and fish, vegetables), feed (for animal husbandry) and bioenergy. As there are many possibilities, further study and possibly technical assistance may be required to select one or more options. However, it is also understood that the World Bank may support part of NWSDB's planned investment in the wastewater management subsector, so that any such activities would need to be well coordinated.

66. The **tenth option** is one of several that addresses emissions resulting from the consumption of grid-based power. By reducing water losses from an estimated 23.3% (estimated from regional support center data that included information on water losses) to a targeted 15%, the amount of water produced can be reduced. This will reduce the amount of energy that needs to be invested in supplying NWSDB's clients with water. The energy saving is estimated at 22,919 MWh, and the resulting emission reductions were calculated through multiplication by the grid emission factor (0.50855 tCO2/MWh).

67. Some research will be needed in the specific measures that are needed to reduce technical water losses. This could be a combination of leak detection and repairs, for example. It will be important to identify options that are effective and have limited investment costs.

68. The **eleventh option** focuses on using gravity flow in water schemes. It is assumed that this option is already being utilized where it could be relevant, and hence a mitigation potential of zero has been assessed.

69. The **twelfth option** focuses on replacing pumps with more energy efficient pumps. Analysis of the available data shows that the average pump efficiency is 60.42%. Replacement with pumps with 80% efficiency likely will have a reasonable IRR and will reduce the consumption of grid supplied power with 83,337 MWh and the resulting emission reductions were calculated through multiplication by the grid emission factor (0.50855 tCO2/MWh).

70. While the proposed replacement program is likely economically attractive, if there are restrictions on availability of financing and/or required economic returns are higher than expected, it could make sense to focus on older pumps and pumps with lower efficiency. The energy efficient pump program can then be more limited in size, leading to somewhat lower emission reductions.

71. Other points to consider are of a practical nature. For example, availability of spare parts for energy efficient pumps is important to ensure that the projected benefits from the energy efficient pumps are realized and that the water supply is not interrupted.

72. The **thirteenth option** involves the construction of solar PV power plants and solar PV rooftops to provide NWSDB with power (and when power is generated that is not used by NWSDB, supply the surplus to the grid. It is one example of renewable energy power plants that and decentralized power plants that NWSDB could consider. Other options include wind energy, biomass-to-power and biogas-to-power.

Table 9. Potential solar PV investments at NWSDB.

RSC	No.	Project Location	Capacity (kW)
Western North	1	Veyangoda WTP	50
	2	Ranpokunuwaththa WTP	85
	3	Ja Ela Area Engineer's Office & Ja Ela Pump House	60
	4	Biyagama Area Engineer's Office	40
	5	Ekala Pipe Store	35
	6	Biyagama Pump House	30
	7	RSC WN - Building Stage 2	20
Western South	8	Dehiwala PH	36
	9	Moratuwa PH	47
Western Production	10	Ambathale WTP	2305
	11	Biyagama WTP - KRB I	900
	12	Biyagama WTP - KRB II	1000
	13	Kethhena WTP	100
	14	Kandana WTP	2220
	15	Kalatuwawa WTP	360
	16	Labugama WTP	150
	17	Bambukuliya WTP	922
Southern	18	Tangalle Water Treatment Plant	100
	19	Muruthawela Water Treatment Plant	60
	20	Kattakaduwa Water Treatment Plant	80
	21	Kirama Katuwana Water Treatment Plant	100
	22	Ruhunupura Water Treatment Plant	100
	23	Ambalantota Water Treatment Plant	100
	24	Sooriyawewa Water Treatment Plant	60
	25	Lunugamvehera Water Treatment Plant	100
	26	Malimbada Water Treatment Plant	170
	27	Hallala Water Treatment Plant	65
	28	Akuressa Water Treatment Plant	65
	29	Hapugala WTP	75
	30	Wakwella WTP	118
	31	Hapugala Reservoir	295
	32	Kowlhena BPH	182
	33	AE Office- Galle	15
Uva	34	Demodara WTP	228
	35	Mahiyanganaya WTP	100
	36	Muthukandiya WTP	60
	37	Girandurukotte WTP	20
	38	Workshop, Monaragala	20
	39	Bandarapura WTP	30
	40	Udawela WTP	11
	41	Ground Water Office	200
Eastern	42	Konduwatuwana WTP	510
	43	Himidurawa WTP	100
	44	Kanthale WTP	400

RSC	No.	Project Location	Capacity (kW)
	45	Vavunathivu WTP	500
	46	Eachchalampattu WTP	100
Northern	47	Eluthoor	80
	48	Oddusuddan WSS	20
	49	Nedunkerny WSS	20
	50	Pokkanai PH	26
	51	Thaiyeddi PH	12
	52	Valvettithurai WSS	23
	53	Adampan WSS	21
	54	Vidataltivu OIC Office	11
	55	Vidataltivu PH	30
	56	Mannar DE Office	28
	57	Vellankulam OIC Office, Mannar	15
	58	Mallavi WSS	30
	59	Pandiyankulam WSS	15
	60	Pungudutivu WSS	34
	61	Poonakary WSS	14
	62	DE (Kilinochchi) Office	40
	63	Kilinochchi WTP	240
	64	DE (Mulaithivu) Office	200
	65	OIC Puthukuduyiruppu Office	50
	66	Kilinochchi Store Building	120
	67	Kaddudai Office Building	24
	68	Velanai Office Building	24
	69	Old Park Office Building	24
	70	Navakuli Office Building	24
	71	Meesalai WSS	236
	72	Nallur WSS	160
	73	Kallundai WSS	100
North Central	74	Nuwarawewa WTP	175
	75	Sacred City WTP	250
	76	Thisawewa Circuit Bungalow	42
	77	Kalawewa WSS	250
	78	Jaffna Junction WSS	100
	79	Wijayapura WSS	100
	80	RSC Office NC	100
	81	Oyamaduwa Plant	64
	82	Galnewa Plant	100
	83	Mihinthale Pump House	65
	84	Eppawala WSS	44
	85	Kanadarawa plant	512
	86	Medawachchiya WSS	41
	87	Thanthirimale Plant	36
	88	Ground water office	140
	89	Medirigiriya Intake	31
	90	Aralaganwila	22
	91	Kaduruwela Purnp House	250
	92	Minneriya Treatment Plant	160
	93	Somawathiya Treatment Plant	64
Central	94	Greater Dambulla WTP	250
	95	Greater Kandy WTP	600
	96	Inamaluwa booster PH	90
	97	Kehelwala BPH	72
	98	Paradeka WTP	97
	99	Ulapane WTP	209
	100	Yatiwala BPH	50
	101	Elpitiya WTP	146

RSC	No.	Project Location	Capacity (kW)
	102	Maskeliya WTP	107
	103	Hatton WTP	45
	104	Marassana WTP	41
	105	Central south WTP	130
	106	Wastewater treatment plant	521
	107	Prospect Hill WTP	230
	108	Gonigoda BPH	37
	109	Gohagoda intake	37
	110	Kandakaduwa BPH	46
	111	Madarangoda BPH	73
	112	Mount Temple BPH	142
	113	Ginigathhena WTP	132
	114	Nawalapitiya WTP	36
	115	Hanthana WTP	27
	116	Mathale WTP	390
	117	Ukuwela WTP	235
	118	Ambangaga WTP	240
	119	Udathenna WTP	103
	120	Rattota WTP	203
	121	Intake of GDWTP	50
North Western	122	Nikawaratiya WTP	100
	123	Bingiriya WTP	180
	124	Giriulla WTP	120
	125	Deduruoya WSS	400
	126	Sewerage TP Kurunagala	155
	127	Bungadeniya PH	120
	128	Chilaw Old WTP	190
	129	Puttalam EWTP	380
	130	Polgahawela WTP	500
	131	Ground water office wariyapola	50
	132	Dankotuwa TP	70
	133	Daduruoya Nagollagama	55
	134	Nelumpokuna WTP	95
	135	Bingiriya intake	40
	136	Wariyapola TP	35
	137	Polgahawela Intake	55
	138	Alawwa Kiriwanpola PH	20
	139	Puttalam Rahamatnager	50
	140	Puttalam Kalladiya PH	80
Sabaragamuwa	141	Kolonna WTP	34
	142	Balangoda WTP	43
	143	Godakawela WTP	24
	144	Udawalawa WTP	50
	145	Ambilipitiya WTP	40
	146	Greater Rathnapura WTP	50
	147	Galigamuwa WTP	150
	148	RM Office – Kegalle	37
	149	Mawanella WTP	75
	150	Moronthota WTP	114
	151	Hiriwaduna WTP	187
	152	Moratuwa/ rathmalana WTP	160
	153	Mt. Lavinia Pumping Station	45
	154	Dehiwala Pumping Station	32
	155	PS-3 Pumping Station at Moratuwa	17
	156	PS - 5 Pumping Station at Rathmalana	19
	157	CEWAS Building – Rathmalana	250
	158	Vavunathivu Ground Mounted Solar	10,000

RSC	No.	Project Location	Capacity (kW)
Total			**34,852**

RSC = Regional Support Center
Source: NWSDB

73. As NWSDB already has some, although limited, experience with solar power and has formulated a solar PV investment plan comprising over 34 MW in solar PV (see Table 9), the solar PV option has been selected. Emission reductions have been projected on the basis of an average of 1400 hours of operation per year and a grid emission factor for intermittent energy of 0.6464 tCO2/MWh[32].

74. The **fourteenth option** involves renewable energy options other than solar PV, such as biomass to power, biogas to power, wind power and hydropower. Especially the latter may be promising. There may be water supply schemes with potential for generating hydropower. Therefore, it is suggestable to consider about the hydropower generation in addition to solar power generation at those particular locations.

B. Proposed mitigation actions

75. Based on the analysis[33] of the longlist of potential mitigation options in the preceding section, the following shortlist of mitigation actions are proposed, including an assessment of the timeline needed for the realization of the investment / action and the estimated potential emission reductions resulting from the action / investment.

Table 10. Shortlist of proposed mitigation actions.

Source of emissions	Mitigation action	Mitigation potential (tCO2/year)
Short-term actions		
Consumption of power supplied by the grid	1. Study on options to reduce technical water losses	NA
	2. Increased pumping efficiency	42,156
	3. Solar PV investment	31,540
GHG emissions from wastewater treatment	4. Investigation of options to mitigate GHG emissions from wastewater treatment and fecal sludge management.	NA
Medium-term actions		
Consumption of power supplied by the grid	5. Reduction of technical water losses – implementation of identified investments leading to the targeted reduction in water losses[34]	11,593
GHG emissions from wastewater treatment	6. Implementation of identified mitigation measures in the	TBD

[32] IFI Dataset of Default Grid Factors v.3.2. See https://unfccc.int/sites/default/files/resource/Harmonized_IFI_Default_Grid_Factors_2021_v3.2_0.xlsx.
[33] The analysis considered, in no particular order: 1) the GHG inventory (addressing a large source of GHG emissions takes priority); 2) NWSDB planning (investments that are known to be considered by NWSDB take priority over others, all other factors considered equal); 3) initial estimate of the return on investment (investments that likely will have attractive returns are prioritized over others); and 4) mitigation contributions (if an options does not result in significant GHG emission reductions it makes little sense to pursue the option).
[34] The average amount of embedded CO2 per m^3 is 0.2123kgCO2/m^3 (considering GHG emissions from pumping energy only).

	wastewater sector	
Diesel for vehicles	7. Study on the suitability of biodiesel NWSDB diesel engines.	NA
Consumption of power supplied by the grid	8. Study on the feasibility of renewable energy other than solar PV	NA
Long-term actions		
Diesel for vehicles	9. Implementation of a switch from diesel to biodiesel – provided biodiesel becomes available and the study mentioned under 7 is positive.	TBD
Consumption of power supplied by the grid	10. Implementation of identified renewable energy options other than solar PV that have adequate payback periods.	TBD
Total (not considering how identified mitigation actions interact)		***85,290***
Total (considering how identified mitigation actions interact)		**81,174**

NA = Not applicable; TBD = To be determined.
Figures may not add up due to rounding
Source: Author's analysis and calculations.

76. Option 1 is a study on the technical options to reduce technical water losses, with the objective to reduce non-revenue water to a target of 15%. The investment options identified through this study are included as a medium-term investment option, see item 5 in Table 10.

77. Options 2 and 3 are relatively straight forward and can be implemented in the short-term. Together they will produce over 73,000 tCO2 emission reductions per year if implemented in full, although it is also possible to anticipate that only part of the programs will be implemented, over a longer time period.

78. Option 4 is a study into the identification of suitable mitigation options related to the wastewater treatment and fecal sludge management subsector. This is associated with NWSDB's role in the implementation of the sanitation master plan. However, this action should be coordinated with other donors, as other donors may already have a wish to support these NWSDB investments with technical support and financing. If a study goes ahead, the study will potentially lead to investments included under item 6 in Table 10. No estimate of potential or likely GHG emission reductions has been attempted.

79. Options 7 and 8 are further studies. Option 7 is a study to assess the suitability of biodiesel for diesel vehicles at NWSDB and should be conducted only if biodiesel becomes widely available in Sri Lanka. If biodiesel becomes widely available and the study does not identify major difficulties in using biodiesel, a switch to biodiesel could be considered (item 9 in Table 10).

80. Option 8 is a study into renewable energy other than solar PV. If suitable investments with attractive payback periods can be identified, these will lead to further emission reductions if implemented (item 10 in Table 10).

VI. POTENTIAL AND PROPOSED ADAPTATION INVESTMENTS

81. It is convenient to start the discussion of potential adaptation investment with a modified version of Table 7 summarizing the main identified risks and vulnerabilities related to climate change as it affects NWSDB. See Table 7

82. The following table provides an overview of the various adaptation options that are available to address these identified climate change challenges to NWSDB. Some effort has been made to select adaptation options that may potentially be within the remit of NWSDB, although the boundaries of NWSDB; however, this would eventually need to be assessed by NWSDB management and other relevant stakeholders in Sri Lanka. The same applies to the eventual recommendations (proposed adaptation investments).

Table 11.

Table 12. Potential NWSDB adaptation investments

Potential adaptation investment	Identified impact addressed (See)	Comments
Short-term investments		
1. Implement NWSDB's part of the sanitation master plan[35].	Impacts 1), 6), and 10)	See the sanitation master plan and Table 13. There are possibilities for combining these investments with mitigation investments that may need to be explored.
2. Construction of upstream reservoirs for drinking water.	Impacts 2), 3), 5), 7), 8), 11), 12), 13), 17), 18), 19), 20), 21), 22) and 25)	Part of NDC 7.4.1, Water Sector-Irrigation Water Sub Sector. See Table 5. Contributions to flood control depend on how the reservoirs are operated.
3. Reducing System Water Losses		
4. Increasing Source Water Availability/Quality		
5. Solving User Conflicts		
6. Promoting Efficient Water Use, Motivation Reuse,		
7. Implement Energy auditing and replacement		
8. Completion of ongoing new drinking water projects		
9. Seek new water sources and options – Surface and sub-surface water		
10. Promoting of rainwater harvesting and ground water recharging,		
11. Identify best solutions (covering technical and financial aspects) for salinity barriers.	Impacts 4) and 5)	Part of NDC 5.1, Water Sector. See Table 5.
12. Monitoring and recording of saline water intrusion into drinking water sources especially during drought periods.	Impacts 4) and 5)	Part of NDC 5.4, Water Sector. See Table 5.
13. New drinking water projects	Impacts 3), 18), 20), and 21)	Part of NDC 2, Water Sector. See Table 5.

[35] Existing and planned support by donors needs to be assessed.

Potential adaptation investment	Identified impact addressed (See)	Comments
14. Seek new water sources and options – Surface and sub-surface water	Impacts 3), 18), 19), 20), 21), 22), and 28)	Part of NDC 2, Water Sector. See Table 5.
15. Prepare, Review, update and prepare disaster management plans and emergency evacuation plans for buildings and Water infrastructure located in flood-, landslide- or tsunami-prone areas.	Impacts 7) and 8)	
Medium-term investments		
16. Increasing Water Supply and Sanitation Coverage		
17. Promote Recycled Water and Rain Water for Non Potable Use		
18. Increasing Source Water Availability		
19. Establish salinity barriers at each critical river identified.	Impacts 4) and 5)	Part of NDC 5.2, Water Sector. See Table 5.
20. For new operational assets and buildings especially in areas with elevated risks of floods, landslides and tsunamis, make siting decisions that lower or eliminate these risks.	Impacts 7), 8), 9), 10), 11), 13), 16), 19), 20), 22), 23) 24) 25) and 28)	For example, this could include siting away from the coast, rivers and large inland water bodies, or at higher elevations, to limit exposure to flood and tsunami risks. It could also include siting that makes use of existing flood barriers and protection (both green and grey).
21. Construct protective measures (grey and green) to protect buildings and operational assets that are sited in areas with elevated risks of floods, landslides and tsunamis.	Impacts 14), 18), 19), and 20)	This includes, for example, protective infrastructure such as flood barriers, slope stabilization measures, and dams and use of green spaces and blue spaces to provide protection.
22. Use of flood resistant materials such as corrosion- and water resistance materials in new constructions	Impacts 6), 7), 18), and 20)	
Long-term investments		
23. Increase shading of storage facilities	Impact 2)	
24. Use non-traditional sources of water, such as treated wastewater, treated brackish water and desalinated seawater.	Impacts 18), 19), and 20)	Promising approaches exist to treat brackish water and wastewater up to drinking water quality while simultaneously producing food, feed and energy.
25. Ground Recharge of Treated WW		
26. Increase in Source Water Availability		
27. Construction of upstream reservoirs for drinking water.		

Source: Author, based on experience and consolidating information in the NDC, sanitation master plan and other sources reflected in preceding sections.

83. Finally, the proposed accompanying soft investments have been included below. Most of these are first priority (short-term), but items XVI, -XXII are second priority (medium-term), and items XXIII, and XVII are third priority (long-term).

84. Several of the investments mentioned above should be uncontroversial because they have already been agreed as part of NWSDB's contributions to the implementation of the NDC (adaptation in the water sector) or because they have been included in the sanitation master plan. Most of the attention in the following paragraphs focus on suggested investments that do not have such "official" justification. However, some of the suggestions may need to be moved to the list of "soft" measures.

85. The investments NWSDB would make in the framework of the sanitation master plan (**option a**) are well defined and can be summarized as below (Table 13). The sanitation master plan also indicates for some of the planned investment sources of funding.

Table 13. NWSDB's planned contributions to the sanitation master plan implementation.

Solution	Number of projects		2021-2023		2024-2025		2026-2030	
	Units	Number	population coverage	Cost (Mln. LKR)	population coverage	Cost (Mln. LKR)	population coverage	Cost (Mln. LKR)
FSM	FSTP	16	20.50%	2,700				
Centralized sewerage	Cities / urban area	55	0.43%	47,267	0.47%	115,686	1.40%	324,050
Total			20.93%	49,967	0.47%	115,686	1.40%	324,050
$ equivalent				152,172,500		352,317,086		986,881,313

FSM = Fecal sludge management; FSTP = Fecal sludge treatment plant; Mln. LKR = Million Sri Lankan Rupees.
Source: NWSDB (undated), Sanitation Master Plan (2021-2030). Amounts in LKR are converted to $ at the rate 1,000,000 LKR = $ 3,045.46 (exchange rate of 26 November 2023).

86. As mentioned in Section V, there are several options to mitigate GHG emissions associated with this program, while the listed investments are adaptation options in their own right. The extent to which the technologies for investments can still be modified, and the extent to which these investments still need investment depends on the status of discussions with potential international financiers.

87. Option b) is one to which NWSDB has already committed. The extent to which option c), *Increase shading of storage facilities and/or cover storage facilities*, is already implemented is unclear. It can easily be incorporated into other options to which NWSDB has already committed (e.g. option b) with limited additional costs.

88. Options d), e) and f) are all part of NWSDB's agreed contributions to Sri Lanka's NDCs. Option g) *For new operational assets and buildings especially in areas with elevated risks of floods, landslides and tsunamis, make siting decisions that lower or eliminate these risks* is an option that is in principle low cost, making use of locational differences in risk exposure and third party investments in protection against risks.

89. Options h) *Construct protective measures (grey and green) to protect buildings and operational assets that are sited in areas with elevated risks of floods, landslides and tsunamis* and i) *Use of flood resistant materials such as corrosion- and water resistance materials in new constructions* are measures to deal with risks of floods, landslides and tsunamis that cannot be addressed through siting decisions and may protect operational assets, buildings and people, whereas option c) *Review, update and prepare disaster management plans and emergency evacuation plans for buildings in flood-, landslide- or tsunami-prone areas* is a measure that will help protect people working in buildings in risk-prone areas. However, this is more properly thought of as a soft measure and will be added to the list of soft measures in the following section.

90. Options k) and l) are already agreed options, and option m), *Use non-traditional sources of water, such as treated wastewater, harvested rainwater, treated brackish water and desalinated seawater*, could complement these options.

91. At the same time, it is desirable to classify the proposed adaptation investments into those that need to be implemented in the short-term, medium-term and Long-term. In order to make this classification, the urgency of the investment as well as existing commitments have been considered.

92. Based on the preceding analysis, the following table of NWSDB adaptation investments is proposed. Note that the time prioritization is preliminary and will need to be reviewed and potentially modified by NWSDB.

VII. SOFT MEASURES COMPLEMENTING THE PROPOSED INVESTMENTS

93. The identification of soft measures to complement the proposed investment discussed in Sections V and VI partially relies on measures that have already been identified as agreed NDC contributions and other soft measures identified above. However, the CCG assessment further informs the soft measures that could complement the hard investments of the previous sections. Referring to Annex 2 makes the following discussion easier to understand.

94. Table 14 summarizes the scores received on the several dimensions of the CCG assessment questionnaire. It is probably a good idea that the KSTA consultants discuss and validate the self-assessments on NWSDB management, with the objectives 1) to conform the correctness of the self-assessment, and 2) to understand for each of the dimensions why NWSDB does not meet the next higher level yet. This is important to narrow down the needed actions. Note that the author did not have the opportunity to discuss and validate the CCG feedback.

Table 14. CCG self-assessment survey results.

Dimension	Answer				Number of answers	Assessed level
	a) (Basic)	b) (Intermediate)	c) (Advanced)	d) (Best practice)		
1 Commitment	3	10	1	0	14	b) Intermediate
2 Accountability	1	10	2	1	14	b) Intermediate
3 Processes	1	10	3	0	14	b) Intermediate
4 Capacity	1	8	5	0	14	b) Intermediate
5 Engagement	1	7	4	1	13	b) Intermediate
6a Disclosure of GHG emissions	9	3	0	0	12	a) Basic
6b Disclosure of low-carbon transition risks and opportunities	8	6	0	0	14	a) Basic
6c Disclosure of physical risks and opportunities	2	10	2	0	14	b) intermediate
7 Validation	8	6	0	0	14	a) Basic

Source: CCG self-assessment survey among NWSDB management

95. It is proposed that the focus of the CCG improvement measures is first to lift the levels of dimensions 6a, 6b, and 7 that are currently 1 (basic) after rounding to 2 (intermediate), addressing the “laggards”, second to lift the levels on dimensions 2, 4 and 5 from level 2 (intermediate) to level 3 (advanced), addressing the dimensions for which the next level is easiest to achieve, and then to address the remaining dimensions, improving from level 2 (intermediate) to level 3 (advanced).

96. With reference to Annex 2 and the definition of the various levels, it is possible to indicate (see Table 15) what may be needed to achieve the increase in levels mentioned in the previous paragraph. However, it may be that part of these suggested actions are unnecessary, as NWSDB may be partly between levels. Finally, it is likely that the proposed measures need the support from a consultant familiar with the CCG framework.

97. The suggestions in Table 15 may be combined with other soft measures that have been mentioned previously. Such measures include *Implement regulatory measures for water fittings* contributing the NDC 4, - *Promote the use of wastewater for gardening, sanitary, construction and other purposes to reduce demand for treated water*; and *Prepare plans for building capacity in each institution to effectively implement the sector NDCs*

including that of community water supply schemes, Awareness raising and behavioral change campaigns for the public towards sustainable use of water as a climate resilience building for water security (lead agency together with MoWS), and *Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities*, all part of NDC 6 - *Capacity building for water sector personnel and public awareness on building resilience to climate change* (both mentioned as part of NWSDB agreed contributions to the NDC.

Table 15. Proposed actions to improve CCG at NWSDB.

Dimension	Action	Period[38]
6a Disclosure of GHG emissions	I. Commit to periodically disclose information on our direct GHG emissions (Scope 1) and indirect GHG emissions from energy use (Scope 2) externally using internationally recognized methodologies and guidance.	1
6b Disclosure of low-carbon transition risks and opportunities	II. Commit to periodically disclose information related to low-carbon transition climate risks and opportunities using internationally recognized methodologies and guidance.	1
7 Validation	III. Commit to periodically report about the climate-related risks and opportunities (low-carbon transition and physical impacts) the organization faces and to validate the process internally.	1
2 Accountability	IV. Appoint a member of the board or senior management with specific responsibility for climate related risks and opportunities, including policy, strategy and information.	2
4 Capacity	V. Apart from building staff capacity, take measures to develop and enhance the board's and executive management's collective knowledge of and resources for climate risks and opportunities identification.	2
5 Engagement	VI. Regularly conduct stakeholder consultations to identify and manage economic, environmental, and social risks (with climate risks and opportunities considered a subset of these). Relevant results are communicated to stakeholders (external and internal) in a transparent way.	2
1 Commitment	VII. Develop and publicly communicate a climate-related strategy / policy and formulate climate-related targets.	3
3 Processes	VIII. Develop and put in place a process to assess climate-related risks and opportunities, including the use of multiple climate scenarios, for multiple timeframes to cover risks and opportunities. These assessments will include consideration of direct and indirect risks and opportunities, specifically those that may manifest themselves through the value chain. Risk management actions will systematically be identified for the priority climate-related risks and opportunities.	3
6c Disclosure of physical risks and opportunities	IX. Commit to disclose quantitative and qualitative information related to physical climate risks and opportunities using internationally recognized methodologies and guidance.	3

Source: Author's analysis.

98. Additionally, it includes *Review, update and prepare disaster management plans and emergency evacuation plans for buildings in flood-, landslide- or tsunami-prone areas* mentioned in as a potential adaptation measure.

[38] Proposed periods are: 1: 2024-2025; 2: 2026-2027; and 3: 2028-2029. After that, it would be proper to conduct a new CCG assessment.

99. Finally, there are some other soft measures that either the author's own experiences show could be useful, in particular creating and maintaining a database of NWSDB assets including water and sanitation infrastructure and buildings[39] which for example would have been useful in the preparation of the CCRR report, or are generally considered good practice to include in water sector adaptation actions, such as improved data collection and forecasting capabilities, climate information services and early warning systems, as well as other soft measures that NWSDB experience shows are justified to be included into the CCRR as soft investments. Compiling these various actions together results in the complete list of Table 16.

Table 16. Proposed soft investments.

Soft investment		Source	Indicative priority
I.	Commit to periodically disclose information on our direct GHG emissions (Scope 1) and indirect GHG emissions from energy use (Scope 2) externally using internationally recognized methodologies and guidance.	CCG Assessment	First
II.	Commit to periodically disclose information related to low-carbon transition climate risks and opportunities using internationally recognized methodologies and guidance.	CCG Assessment	First
III.	Commit to periodically report about the climate-related risks and opportunities (low-carbon transition and physical impacts) the organization faces and to validate the process internally.	CCG Assessment	First
IV.	Appoint a member of the board or senior management with specific responsibility for climate related risks and opportunities, including policy, strategy and information.	CCG Assessment	Second
V.	Apart from building staff capacity, take measures to develop and enhance the board's and executive management's collective knowledge of and resources for climate risks and opportunities identification.	CCG Assessment	Second
VI.	Regularly conduct stakeholder consultations to identify and manage economic, environmental, and social risks (with climate risks and opportunities considered a subset of these). Relevant results are communicated to stakeholders (external and internal) in a transparent way.	CCG Assessment	Second
VII.	Develop and publicly communicate a climate-related strategy / policy and formulate climate-related targets.	CCG Assessment	Third
VIII.	Develop and put in place a process to assess climate-related risks and opportunities, including the use of multiple climate scenarios, for multiple timeframes to cover risks and opportunities. These assessments will include consideration of direct and indirect risks and opportunities, specifically those that may manifest themselves through the value chain. Risk management actions will systematically be identified for the priority climate-related risks and opportunities.	CCG Assessment	Third
IX.	Commit to disclose quantitative and qualitative information related to physical climate risks and opportunities using internationally recognized methodologies and guidance.	CCG Assessment	Third
X.	Implement regulatory measures for water fittings.	NWSDB contributions to NDC 4.2, Water Sector; see Table 5	First
XI.	Prepare plans for building capacity in each institution	NWSDB contributions	First

[39] Maintaining data which may be elaborated upon in the CCIT, but including when they were built, where they are located, when they have been harmed by climate change events and to what degree, etc.

Soft investment		Source	Indicative priority
	to effectively implement the sector NDCs including that of community water supply schemes.	to the NDC 6.2, Water Sector; see Table 5	
XII.	Awareness raising and behavioral change campaigns for the public towards sustainable use of water as a climate resilience building for water security.	NWSDB contributions to the NDC 6.3, Water Sector; see Table 5	First
XIII.	Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities.	NWSDB contributions to the NDC 6.6, Water Sector; see Table 5	First
XIV.	Review, update and prepare disaster management plans and emergency evacuation plans for buildings in flood-, landslide- or tsunami-prone areas.	Analysis of NWSDB risk exposure	First
XV.	Creating and maintaining a database of NWSDB assets including water and sanitation infrastructure and buildings.	Author's experience	First
XVI.	Improve data collection and forecasting capabilities.	General experience	Second
XVII.	Develop climate information services and early warning systems.	General experience	Second
XVIII.	Enhancing the implementation of Climate Resilient Water Safety Plan and Sanitation Safety plan	General experience, NWSDB experience	First
XIX.	Good Stakeholder coordination for increase water use efficiency programme	General experience, NWSDB experience	First
XX.	Increase QA/QC for new Projects	General experience, NWSDB experience	First
XXI.	Catchment Protection Programmes and WQ surveillance	General experience, NWSDB experience	First
XXII.	Research & Development studies and Piloting outcomes	General experience, NWSDB experience	First
XXIII.	Energy Auditing/ Monitoring of Specific Energy Consumption (SEC) of All Water Supply Schemes	General experience, NWSDB experience	First
XXIV.	Implement the CCIT development plan including the development of a database to track climate change related parameters and impact to water infrastructure and consumers to arrive in adaptation decisions. See the accompanying report on the CCIT development plan.	Author's experience, NWSDB feedback	First

Source: Compiled by the author based on the preceding analysis and author's, general, and NWSDB experience.

VIII. THE ROLE OF CARBON CREDITS

100. At the request of NWSDB, a section on how carbon credits could support the implementation of GHG mitigation projects has been included in the CCRR. This is relevant, because the sale of carbon credits can be a potential source of revenues for NWSDB, which could help in the implementation of the projects. The first section provides a general set of comments on the role of carbon credits in decarbonization of the water sector, followed by a section that draws out the main implications for the mitigation measures in the CCRR for NWSDB. We have also included a short section on the Water Benefit Standard, which is in approach similar to carbon credits, but then applied to sustainable water supply and/or water loss reduction.

A. General comments on carbon credits and decarbonization of the water sector

101. Voluntary carbon markets and Article 6 of the Paris Agreement offer opportunities to translate greenhouse gas emission reductions into a revenue stream that can help to realize the mitigation investments. These mechanisms, together referred to as carbon credits, can support decarbonization of the water sector, and it is therefore proper to provide some background on these mechanisms, a short description of the general process through which the emission reductions are created, and some practical suggestions how to use the mechanisms.

102. Article 6 of the Paris Agreement (Article 6 for short) foresees the international transaction of mitigation outcomes either through bilateral mechanisms (Article 6.2) or multilateral mechanisms (Article 6.4[40]) in a manner that ensures the internationally traded mitigation outcomes can 1) count towards the NDC commitments of the purchasing country and 2) cannot count towards the NDC commitments of the selling country.

103. Voluntary carbon markets are based on standards such as Verra/VCS[41], Gold Standard, and the Global Carbon Council standard, each of which has its own procedures and eligibility rules. The product traded is verified emission reductions (with specific names depending on the standard chosen), which can be used by organizations and events for PR and CSR reasons and to fulfill voluntary greenhouse gas emission reduction targets. However, emission reductions traded in the voluntary carbon markets generally cannot be used for compliance purposes.

104. The Clean Development Mechanism (CDM) can be considered the mother or grandmother of all these mechanisms. The various voluntary carbon market standards mentioned above derive most of their procedures and methodologies (on the latter, see below) from the CDM. The CDM is also directly inspiring the current development of the multilateral Article 6 mechanism foreseen in Article 6.4 of the Paris Agreement. The CDM also inspired the Japanese Joint Crediting Mechanism (JCM), which in turn predated and inspired the current development of the bilateral Article 6 Mechanism foreseen in Article 6.2 of the Paris Agreement. A short description of the CDM development process can therefore be helpful in understanding how all of these instruments may be used, although details could differ[42].

[40] https://unfccc.int/process-and-meetings/bodies/constituted-bodies/article-64-supervisory-body
[41] The Verified Carbon Standard or VCS is one of the standards maintained by Verra.
[42] Note also that the description given here is general. There are some nuances and differentiation of procedures that have not been presented here.

105. The CDM foresees the development of registration documentation, typically the Project Design Document (PDD)[43]. The PDD provides information on the project, the project owner, consultation processes during the development of the project, and compliance with regulations, including environmental regulations. For the purpose of the creation of the carbon credits, the recognized emission reductions, the key parts of the PDD are the additionality argument (in essence, a demonstration that the project would not have occurred in absence of the incentive resulting from the anticipated sale of the recognized emission reductions), the description of the baseline (what would have happened in absence of the project and the resulting expected baseline emissions), the description of the anticipated project emissions and emission reductions and the description of the monitoring plan (the processes for monitoring the amount of baseline emissions, project emissions and the emission reductions).

106. The PDD needs to be developed according to specific formats, the additionality argument needs to comply with specific tools and guidance, while the baseline and monitoring need to be developed according to specific methodologies, which depend on the type of project that is contemplated. Preparing the PDD requires skills and practice, and is therefore normally done by a consultant or the buyer of the carbon credits, although nothing formally prevents the project owner from preparing the PDD. In all cases, the development of the PDD will have a cost attached to it, whether an opportunity cost of resources (in case of own development by the project owner) or financial costs (when the PDD is prepared by a consultant).

107. In all cases, the PDD needs to be validated by a qualified independent organization the designated operational entity (DOE), which could be seen as a GHG auditor. The DOE checks for compliance with the rules, procedures, guidance and methodologies of the CDM. There are several DOEs, and depending on the sectoral scope of the project and the accreditation of the DOE, any of these DOEs could be contracted for the validation (at a cost). Generally, validation requires a back and forth on the PDD to clarify parts, modify others, and provide evidence. Again, nothing prevents the project owner from dealing directly with the DOE, but generally this is done by the consultant or buyer, because of the skills and practice required.

108. Upon successful completion of the validation (a validation report with a positive recommendation for registration), the project participants (typically project owner and buyer) need to pay a registration fee. Upon the payment of the registration fee, the process of registration starts, including a completeness check and a possibility for the CDM Executive Board (EB) members to raise questions and concerns. If issues are raised, these will need to be answered by the DOE, project owner, buyer, and / or consultant. Note that registration is not automatic, projects may be rejected.

109. After successful registration and the physical implementation of the project, monitoring data will need to be collected, stored and processed according to the monitoring plan and periodically processed into a monitoring report (again, in compliance with the monitoring plan). The monitoring report will among others state the monitored baseline emission, project emissions, and emission reductions. As with the PDD, the monitoring report is usually prepared by a consultant, at a cost.

110. Each monitoring report will need to be verified by a DOE against the methodologies, tools, procedures and guidance of CDM and against the PDD, in a process that is similar to

[43] For reasons of space this short section focuses on projects. CDM also foresees the possibility to develop programs, with slightly different procedures and terminology.

the validation of the PDD. The services of the DOE come at a cost, and the process or verification requires a back-and-forth that may require a significant amount of time.

111. Upon successful completion of the verification (a verification report with a positive recommendation for issuance), the project participants (typically project owner and buyer) need to pay an issuance fee. Upon the payment of the issuance fee, the process of issuance starts, including a completeness check and a possibility for the CDM Executive Board (EB) members to raise questions and concerns. If issues are raised, these will need to be answered by the DOE, project owner, buyer, and / or consultant. Note that issuance is not automatic, issuance may be rejected. If all is approved, the recognized emission reductions, in the case of CDM called certified emission reductions (CERs) will be issued. When the CERs are delivered to the buyer of the CERs, the buyer will pay for the CERs.

112. The process outlined involves at various points costs that need to be made to create the recognized emission reductions, *in casu* the CERs. These costs only to a limited extent depend on the size of the project as measured by the expected amount of emission reductions. This means that in general, the project needs to have a certain size to make it worthwhile to go through the process of creating the emission reductions.

As a rule of thumb, pursuing the registration and issuance of carbon credits by a project may make sense if the total expected amount of emission reductions exceeds 10,000 tCO2e per year.

113. The process outlined involves at various points costs that need to be made to create the recognized emission reductions, *in casu* the CERs. These costs only to a limited extent depend on the size of the project as measured by the expected amount of emission reductions. This means that in general, the project needs to have a certain size to make it worthwhile to go through the process of creating the emission reductions.

114. Each of the various market segments and standards have their specific pros and cons. Article 6 transaction generally carry higher prices (20-30 $/tCO2e) than voluntary market transaction (2-15$/tCO2e), but the Article 6 market is currently less liquid and less transparent than the voluntary carbon market, requires host country rules for Article 6 participation to be in place, and targets mostly host countries that are deemed to have ambitious NDCs. Note that this may change when the mechanism for Article 6.4 of the Paris Agreement becomes operational.

115. The voluntary market is lower priced, and has some pricing characteristics, based on buyer's appetite, that are not "logical" from the viewpoint of mitigation contributions and which are outlined below. Especially for the carbon credits with lower price expectations (more to the right in the second and third bullet), trying to develop according to Article 6 makes sense.

- Gold Standard > Verra/VCS > GCC
- Afforestation and Reforestation (Ecosystem restoration) > avoided deforestation and forest degradation > Methane avoidance and methane utilization > renewable energy > energy efficiency
- African LDCs > African non-LDCs and non-African LDCs > Non-African non-LDC developing countries[44] other than the Big 4 > Brazil and Turkey > India > China

116. The voluntary market is also subject to price fluctuations that could be considered "fads". For example, for some time projects that focus on avoiding or limiting deforestation

[44] "Developing countries" in a UNFCCC sense, countries that do not belong to Annex 1.

and forest degradation have been quite popular; following several negative publications, however, the market appetite for avoided deforestation and forest degradation has severely declined. Prices are also fluctuating a lot; a couple of years back, there was a supply shortage and prices increased sharply, while nowadays there is an oversupply in the market.

117. Pursuing the registration and issuance of carbon credits requires choices regarding the standard to be used, the market to be targeted, and knowledge about what parties may be interested in buying the carbon credits. This requires specialized knowledge that may be obtained from a carbon credit developer or consultant.

It is advisable to take a carbon credit developer (consultant) on board early on to provide advice on the process and strategy for carbon credit development. This can be on a success (percentage) basis and in that case should typically be somewhere in the 15-20% range.

118. Pursuing registration and issuance of carbon credits also carries the risk of failure, in the sense that the project will need to incur carbon credit-related costs (as described above) may fail to successfully register or to successfully issue carbon credits, may fail to generate emission reductions, and may fail to sell (at all or more likely, to sell at prices that are attractive enough). To manage those risks, it is often advisable to get a buyer on board early on.

It is advisable to sign an agreement with a buyer at an early stage. The buyer can be requested to cover all or part of the transaction costs (consultant costs for PDD and monitoring, DOE costs for validation and verification, registration fee, issuance fee), to be deducted from the payment for carbon credits delivered. A carbon credit developer (consultant) can help in the selection of and contract negotiation with a carbon credit buyer.

119. Based on the points raised above, carbon credits of various types can improve income streams from mitigation projects in the water sector and hence contribute to decarbonization of the water sector and could be pursued by the water sector ministry or by water utilities. **The following seven steps are recommended**:

- Step 1. Prepare a carbon footprint for the complete water cycle (from source to disposal after wastewater treatment, so that it is known how large total GHG emissions are, and what the main sources of GHG emissions are. If total emissions are below 100,000 tCO2e, it is better to seek bundling with other project owners. If total emissions are above 100,000 tCO2e, continue.
- Step 2. Calculate emissions per m3 of water. These are the embedded GHG emissions of water, which provides information about how much reducing water consumption will contribute to mitigation of GHG emissions.
- Step 3. Identify GHG mitigation options in the water sector and quantify how many emission reductions each could achieve. Focus on the main sources of GHG emissions. In most cases, the most promising areas for emission reductions include, in this order:
    - Water efficiency and conservation
    - Methane avoidance and methane capture and utilization
    - Energy efficiency and fuel switch (in particular switch from diesel to electrical pumps, and improvement of the efficiency of the pumps)
    - Renewable energy for power supply.
    - Additional measures could be considered on a case-by-case bases, e.g. rewetting of drained wetlands and peatlands, mangrove restoration, etc.
- Step 4. Aggregated identified mitigation options (see Step 3) to create one or more bundles of more than 10,000 tCO2e emission reductions per year. If this is not possible,

aggregate with other sources of emission reductions or stop. If one or more bundles of at least 10,000 tCO2e can be constructed, continue.

- Step 5. Select a carbon credit developer (consultant) and request the carbon credit developer (consultant) to develop a carbon credit development strategy limiting the risk exposure of the project owner.
- Step 6. Request the carbon credit developer to identify carbon credit buyers through a competitive process, in line with the agreed strategy, and with the condition that the buyer covers the transaction costs.
- Step 7. Continue the process with the development of the PDD and the other steps as mentioned above (Paragraphs 104-110).

B. Carbon credits and the CCRR

120. Most what was mentioned above at the general level applies to NWSDB and the CCRR as well. In particular, several of the steps mentioned in the previous paragraph to identify mitigation options have been followed explicitly or implicitly. One of the questions that now need to be answered is what standards can be used for the development of projects as sources of carbon credits.

121. First, Sri Lanka is not an LDC. This limits eligible technologies. Grid-connected solar PV (other than floating solar PV) in non-LDCs are not eligible under VCS and Gold Standard, and the same holds for windpower. These projects types are, however, eligible under the Global Carbon Council (GCC standard)

122. Sri Lanka also has its own national carbon credit standard, the Sri Lanka Carbon Crediting Scheme (SLCCS)[45]. As stated on its website, SLCCS is a national offset scheme established for supporting local clean projects to benefit from climate finance for the Greenhouse Gas emission (GHG) reduction. The scheme is developed with well-defined provisions to enhance credibility, transparency and quality of emission reduction in Sri Lanka. In an era where vast opportunities are growing for low cost GHG reduction projects, SLCCS enables to bring multiple benefits to environment, society and economy.

123. This said, one of the difficulties with the SLCCS is that it is not a very well-known standard. This limits the liquidity of the market, and it is unclear whether attractive carbon credit prices can be obtained under the SLCCS.

Table 17. Carbon credit development recommendation.

Mitigation action (numbering corresponds to Table 10)	Recommended standard	Price expectation ($/tCO2)	Expected emission reductions (tCO2e/yr)	Gross revenue expectation ($/year)
2. Increased pumping efficiency	1. Article 6.2	20.0	42,156	843,128
	2. Article 6.4	20.0		843,128
	3. Verra VCS or GS	3.0		126,469
3. Solar PV investment	1. Article 6.2	25.0	31,540	788,506
	2. Article 6.4	25.0		788,506
	3. GCC	3.0		94,621
5. Reduction of technical water losses – implementation of identified investments leading to the targeted reduction in water losses	SLCCS	1.0	11,593	11,593
6. Implementation of	1. Article 6.2	30.0	TBD	TBD

[45] https://www.climatefund.lk/slccs

Mitigation action (numbering corresponds to Table 10)	Recommended standard	Price expectation ($/tCO2)	Expected emission reductions (tCO2e/yr)	Gross revenue expectation ($/year)
identified mitigation measures in the wastewater sector	2. Article 6.4	30.0		TBD
	3. Verra VCS or GS	5.0		TBD
9. Implementation of a switch from diesel to biodiesel – provided biodiesel becomes available and the study mentioned under 7 in Table 10 is positive.	1. Article 6.2	20.0	TBD	TBD
	2. Article 6.4	20.0		TBD
	3. Verra VCS or GS	3.0		TBD
10. Implementation of identified renewable energy options other than solar PV that have adequate payback periods.	1. Article 6.2	25.0	TBD	TBD
	2. Article 6.4	25.0		TBD
	3. GCC	3.0		TBD

GCC = Global Carbon Council Standard; GS = Gold Standard; VCS = Verified Carbon Standard; SLCCS = Sri Lanka Carbon Crediting Scheme
Source: Author's analysis and calculations.

124. Finally, the scale of the proposed mitigation actions is not very large. This could potentially be a handicap for transactions under Article 6.2 (bilateral) and Article 6.4 (multilateral) of the Paris Agreement, where usually the focus is on larger volumes. Considering all these aspects, the carbon credit standards and price expectations indicated in Table 17 would be reasonable for the mitigation actions proposed under the CCRR.

125. When NWSDB decides to implement one or more of the proposed mitigation actions, the following steps are recommended if NWSDB wishes to gain revenues from the sale of carbon credits:

- Appoint a consultant with considerable carbon market experience to advise on whether entering the carbon credit development trajectory is advisable (market conditions change rapidly, so the current analysis may become outdated).
- Explore the recommended standards and update the recommended standard if appropriate.
- Where several standards are indicated, these are listed in order of priority to be explored. The general order of priority is Article 6.2, followed by Article 6.4, followed by voluntary market standards.
    - Currently Article 6.2 is operational, and several bilaterals are in the market for carbon credits under Article 6.2 (for example, Japan, Norway, Singapore, and Switzerland).
    - If a transaction under Article 6.2 cannot be identified, it makes sense to next explore Article 6.4. Article 6.4 is not yet operational; therefore two things will need to be checked on the Article 6.4 website[46] with priority: 1) Whether the multilateral mechanism has become operational; and 2) whether an approved methodology exists for the project type.
    - If both Article 6.2 and Article 6.4 are unavailable, next the international voluntary market standards are explored. For renewable energy the recommended standard is the GCC standard (VCS and GS do not apply to solar PV in Sri Lanka, with the exception of floating solar), while for energy efficiency VCS and Gold Standard are recommended as equal options.
    - It should be noted that at least in the case of VCS and Gold Standard, there are pathways to start a project under the VCS and Gold Standard and then move it later under the Article 6 mechanism.

[46] https://unfccc.int/process-and-meetings/bodies/constituted-bodies/article-64-supervisory-body

- In the case of reduction in water losses leading to GHG mitigation, the recommendation is to use SLCCS if any carbon credit development is pursued. The reason for this recommendation is that the project is too small for the recognized international standard, combined with the difficulty of finding appropriate methodologies for the quantification of the emission reductions in line with the requirements of the standards.

C. Water Benefit Standard

126. The Water Benefit Standard (the WBS)[47] is a relatively new mechanism developed by the Gold Standard focusing on water supply and water saving. Projects that could benefit from include:

- Water supply,
- Water purification and/or
- Water conservation.

Note that energy efficiency and renewable energy projects are excluded from the WBS. WBS focuses on water exclusively.

127. All projects must use an approved methodology for quantifying the outcomes of the project. All projects must ensure they are aware of, and address the following issues within the watershed:

- Water balance.
- Water scarcity.
- Water sensitivity.
- Environmental integrity and sustainable development

128. The PDD describes the project in detail and explains how it meets the requirements. A project must prepare a Project Design Document as per the templates and guidelines provided by the Gold Standard. Where useful, claims in the PDD should be backed by supporting documents, e.g. scientific reports, copies of contracts, meeting minutes, pictures, maps, etc. The PDD together with the supporting documents form the base of information for the certification process, which proceeds analogously to the CDM.

129. For NWSDB, the relevant projects focus on water conservation, through reducing technical losses and potentially through water saving devices installed with end-users. These can result in WBS certificates that could be sold in the market. However, a precondition for the realization of WBS certificates is the availability of suitable methodologies to quantify sustainable water impact, which does not appear to exist yet.

130. Potential buyers may include member of the Water Benefit Partnership, who have supported the development of the Water Benefit Standard: Bayer, Nestlé, Munich RE, Borealis, Coop, Olam, Carlsberg Group, IUCN, Global Water Challenge, SGS, International Federation of Red Cross and Red Crescent Societies, Markit, Limno Tech, Bonneville Environmental Foundation, Quantis, Climate Care, World Vision Australia and World Vision Germany.

131. If NWSDB wishes to pursue this approach, a first step after assessing the amount of water savings that could be achieved through identified investments could be to discuss with

[47] The description and analysis of the WBS is based on the following sources: The Gold Standard. Undated. *The Gold Standard Water Benefit Standard Requirements (beta)*; The Gold Standard. 2016. *Gold Standard Methodology for Accreditation of Water Benefit Certificates Water Access and Water, Sanitation and Hygiene (WASH) Projects V 1.0*; and The Gold Standard. Undated. *Sustainable Sugarcane Initiative Methodology to Quantify Water Efficiency Outcomes from Seedling Nurseries (beta)*. See also https://www.goldstandard.org/our-story/sector-water-benefits.

ADB to ascertain whether ADB would be willing and able to provide support, for example for the development of relevant methodologies to quantify the impact of investments to reduce technical losses of water. If ADB is not interested, the organizations indicated in the previous paragraph could be pursued.

IX. FINANCING PLAN

132. The proposed specific actions of the CCRR are described in three tables, Table 10 for mitigation investments, for adaptation investments, and Table 16 for accompanying soft measures. These proposed interventions will need to go through a validation process by NWSDB management in which some of the proposals may be removed, some added, some modified, and in which NWSDB will also provide their investment cost estimates and available financing (from the government of Sri Lanka and from international financial institutions). Finally, some of the proposed investments are subject to confirmation through studies that would be conducted before their implementation.

133. However, it is reasonable to expect that also after this process, new financing required will remain high. A first estimate would be over $60 million for mitigation, over $400 million for adaptation, and $2 million for accompanying soft measures.

134. For various reasons it will be difficult to fill these financing requirements from traditional sources. Sri Lanka's macroeconomic financial situation is not very good, so that it will be difficult to attract financing from e.g. international financial institutions. Moreover, the adaptation investments will not lead to additional revenues that can be used to repay loans, while the mitigation investments mostly will result in either cost savings or revenues that are both in local currency, which does not help service loan nominated in hard currencies.

135. This reality leads to two recommendations for the financing plan. One would be to aim for a stable long-term financing framework that allows for multiple approvals over time. As the commitments of the government of Sri Lanka would be more limited, it also becomes easier to make such commitments. For example, ADB's multi-tranche financing facility (MFF) supports complex projects that require a larger investment and longer commitment than a regular project loan could provide. ADB provides a series of tranches when the investments are ready and the borrower requests financing. The MFF can finance multiple projects under an investment program in a sector or in various sectors, as well as large standalone projects with substantial and related individual components with long-term implementation plans. It can also finance slices of long-term contract packages.

136. It would also be advisable to aim for Green Climate Fund (GCF) financing of the CCRR. The GCF funding would complement financing provided by the government of Sri Lanka and already secured funding from other sources. It would have high concessionality, especially for the adaptation component of the CCRR.

137. Accessing the GCF requires finding a willing Accredited Entity (AE) able to handle a program of the indicated size. Usually, the AE will also provide part of financing. The total financing picture may be that 40% of new adaptation financing need would come from the GCF in the form of grant, and 30% in the form of a highly concessional loan, with 30% in the form of a "normal" IFI loan. For new mitigation finance, perhaps 50% would come from the GCF as a highly concessional loan, and 50% would be a traditional IFI loan. All soft measures would be financed from grants. Combining this with the indicated new financing needs would result in:

- GCF Grants: $162 million
- GCF highly concessional loans: $150 million
- IFI standard loan: $150 million

138. Any such approach would need to be well coordinated within the Sri Lankan government. It may be that MoWS would be interested in pursuing a larger program that is based on the resilience needs of several water sector government organization, or that

would implement a sector wide climate resilience roadmap. Also, the Sri Lankan National Designated Authority (NDA) for the GCF (Ministry of Environment, primary Dr. Anil Jasinghe, Secretary) would need to be consulted and brought on board.

139. As mentioned, any such application to the GCF would need to be channeled through an AE to the GCF, which requires identifying a suitable AE[48] and obtaining the AE's interest. The proposed program will need to match the AE priorities, and the same for the approach chosen in the program. Therefore, it is generally not a good idea to approach a potential AE with a full-fledged proposal. Instead, it is better to approach AEs in an early stage so that more discussion and joint development of the proposal becomes possible. Also important to consider is that many AEs will gave made commitments to provide climate finance, which means that they are looking to finance investments in which they can claim a large amount of climate finance in accordance with their climate finance tracking methodologies.

140. A good practice taking this lesson on board is to approach AEs with a pre-concept note of about 5-10 pages that focuses on how the proposed financing addresses climate change. In general, the pre-concept notes will describe:

- Program title, sector(s) covered, geographical scope, counterparty, contact information.
- The current situation and practices in the sector(s) covered in the program;
- The climate change challenges to be addressed; and the means to address it.
  In the case of the CCRR, the best tactic is probably to present the project as an adaptation project with mitigation co-benefits. Therefore, present the relevant parts of the information on long-term projections of climate change in Sri Lanka and on impacts of climate change on sectors and regions. State that "*the objective of the proposed program is to reduce these adverse impacts of climate change"*. Describe the means to address the negative impacts identified, explaining how the proposed measures will reduce these negative impacts.
- Co-benefits.
  Other sustainable development benefits from the program, such as mitigation contributions, environmental co-benefits, social co-benefits, economic co-benefits, contributions to the various SDG goals.
- Preliminary information on the investment costs, the O&M costs, and the benefits.
- The rationale for international support,
  This needs to provide a preliminary answer as to why the program needs international support to be implemented. This likely needs to center on the various barriers that make the implementation without support very difficult. High costs of the measure could be one type of barrier, but the best barriers to mention are ones that are temporary and could be reduced over time.
- The key outcomes and outputs expected as well as climate resilience, GHG mitigation and other indicators.
- Upscaling and replication.
  This should answer the following questions: What are the possibilities for an expansion of the program, or a replication of the program, with no or more limited support? What measures are included in the program to mobilize financing in the targeted sector, including from the domestic and international private sector? What parallel efforts are under way to mobilize additional finance?

141. The pre-concept notes will be relatively short but will make the case of the investment and show that it is motivated to address climate change. The pre-concept notes would cover the physical investments, but also the capacity building, policy development and other "soft measures" needed to make the programs work. The soft measures would aim at reducing or eliminating barriers towards the replication and scaling up of the investments

[48] A full list of GCF AEs is available on https://www.greenclimate.fund/about/partners/ae.

proposed in the pre-concept notes and measures to bring in additional sources of climate finance.

142. Pulling the different strands of the argument together, the concessional finance options that best fit with NWSDB CCRR are climate finance, and especially GCF given the scale of the required finance; with ADB an attractive intermediary (Accredited Entity in GCF terminology), in particular given the finance programs it already targets towards the water sector in Sri Lanka and its aggressive climate finance goals; and to a lesser extent, revenues from the sale of carbon credits and Water Benefit Standard credits.

143. To obtain maximum benefit from mitigation and adaptation measures, the people responsible for planning and detailing investment projects need to be trained, with a focus on preparation of project investment concept notes to suitable to attract the interest of accredited entities such as ADB. The concept notes would need to include 1) a link between the investment and climate change challenges, 2) a demonstration of additionality (an argument that concessional climate finance is needed to make the project happen), 3) a barrier analysis and a theory of change, 4) arguments about replication and scaling up of the investment with more limited concessional climate finance support, 5) an initial overview of the MRV arrangements, and 6) quantification of mitigation outcomes. There is no need to build capacity for the preparation of the full funding proposals, as the preparation of the funding proposal would be a one off.

144. The capacity needs to be built for corporate climate governance improvement, which means a focus on the organizations processes and hence training for medium and senior management. Preparedness to deal with climate change challenges may become a pre-condition for accessing any form of finance in the near future, including climate finance.

X. CONCLUSIONS

145. This report includes the climate change impact to NWSDB giving an overview of the sources of GHG emissions and an overview of the climate change challenges requiring mitigation and adaptation actions. See Table 1 and Table 7, for further details.

146. Total GHG emissions are estimated at present is almost 215 thousand tCO2e per year. Of this amount, the most important sources are GHG emissions from power consumed (177,013 tCO2e/year) and GHG emissions from the use of diesel in vehicles (30,829 tCO2e/year).

147. The main NWSDB climate-related challenges are summarized below:

Increased temperatures

1) Increased risk to health through increased spread of pathogens
2) Increased evaporative losses from water sources
3) Increased demand for water may put stress on the NWSDB supply system

Sea level rise

4) Increased saltwater intrusion;
5) Lower quality water resources due to increased salinity requiring more and more costly treatment
6) Increased risk to health through increased spread of pathogens

Increase in precipitation or increased frequency of extreme precipitation events and storm surges

7) Increased risk of flooding resulting in damage to NWSDB operations and assets.
8) Increased risk of damage due to flooding and/or landslides
9) Increased risk of rising water tables exposing underground structures to ground movements and flotation, which could cause structural damage and inundation; increased risk of septic tanks and pit latrines flooding or filling with silt.
10) Increased risk to health through increased spread of pathogens
11) Danger to users of NWSDB buildings resulting from flooding and/or landslides
12) Intake blockages due to silt and floating objects
13) Inaccessibility to operators of NWSDB Intakes / buildings resulting from flooding.
14) Additional treatment costs due to poor source water quality
15) Power failures due to extreme weather
16) Increased risk of source water quality depletion resulting plant shutdown and revenue loss
17) Interruption of source water extraction due to dislocation of floating intakes

Drought

18) Increased risk to temporary shortages of water in drought periods.
19) Decrease in surface and groundwater availability
20) Water scarcity
21) Increased water demand
22) Increased competition with other water users
23) Water quality deterioration due to low dilution and algae proliferation.
24) Additional cost for water treatment, increased pumping and bowser supply
25) Increased saltwater intrusion due to low flow in rivers
26) Difficulty of source water extraction using floating intakes
27) Diversion of flow of rivers from direct intake locations
28) Low pressure in distribution systems due to increased water consumptions

148. On the basis of these, longlists of potential mitigation and adaptation measures were prepared, which were then narrowed down to shortlists of proposed mitigation and adaptation measures. A list of accompanying soft measures was prepared on the basis of a climate corporate governance assessment, NWSDB's NDC commitments, and experience. The proposed specific actions of the CCRR are described in three tables, Table 10 for mitigation investments, for adaptation investments, and Table 16 for accompanying soft measures.

149. The proposed mitigation actions are presented below. It consists of a mix of studies related to mitigation investments (which may lead to subsequent investments) and investments, with the expected mitigation estimated at 81,174 tCO2e/year (over 81 thousand tCO2e).

Proposed mitigation actions – Short-term

1. Study on options to reduce technical water losses
2. Increased pumping efficiency
3. Solar PV investment
4. Investigation of options to mitigate GHG emissions from wastewater treatment and fecal sludge management.
5. Catchment Protection and awareness programs

Proposed mitigations action – Medium-term

6. Reduction of technical water losses – implementation of identified investments leading to the targeted reduction in water losses
7. Implementation of identified mitigation measures in the wastewater sector
8. Study on the suitability of biodiesel NWSDB diesel engines.
9. Study on the feasibility of renewable energy other than solar PV

Proposed mitigation actions – Long-term

10. Implementation of a switch from diesel to biodiesel – provided biodiesel becomes available and the study mentioned under 7 is positive.
11. Implementation of identified renewable energy options other than solar PV that have adequate payback periods.

150. Below the proposed adaptation investments are presented with an indication of their priorities (short-term, medium-term and long-term) considering urgency of action and existing NWSDB commitments. This prioritization in time will need to be confirmed and, if necessary, modified by NWSDB. Note that systematic collection of climate relevant data is important to inform adaptation investment decision-making. This has been included as a first priority soft measure as discussed below (Next paragraph, item XXIV).

Proposed adaptation investments

<u>Short-term</u>

i. Implement NWSDB's part of the sanitation master plan[49].
ii. Develop database to track climate change related parameters and impact to water infrastructure and consumers to arrive in adaptation decisions
iii. Creating and maintaining a database of NWSDB assets including water and sanitation infrastructure and buildings
iv. Construction of upstream reservoirs for drinking water.
v. Identify best solutions (covering technical and financial aspects) for salinity barriers for each case.

[49] Existing and planned support by donors needs to be assessed.

vi. Establish salinity barriers at each critical river identified.
vii. Monitoring and recording of saline water intrusion into drinking water sources especially during drought periods.
viii. New drinking water projects
ix. Seek new water sources and options – Surface and sub-surface water

Medium-term
x. For new operational assets and buildings especially in areas with elevated risks of floods, landslides and tsunamis, make siting decisions that lower or eliminate these risks.
xi. Construct protective measures (grey and green) to protect buildings and operational assets that are sited in areas with elevated risks of floods, landslides and tsunamis.
xii. Use of flood resistant materials such as corrosion- and water resistance materials in new constructions

Long-term
xiii. Increase shading of storage facilities and/or cover storage facilities.
xiv. Use non-traditional sources of water, such as treated wastewater, harvested rainwater, treated brackish water and desalinated seawater.

151. Finally, the proposed accompanying soft investments have been included below. Most of these are first priority (short-term), but few items are second priority (medium-term), and few items are third priority (long-term).

Proposed accompanying soft investments
I. Commit to periodically disclose information on our direct GHG emissions (Scope 1) and indirect GHG emissions from energy use (Scope 2) externally using internationally recognized methodologies and guidance.
II. Commit to periodically disclose information related to low-carbon transition climate risks and opportunities using internationally recognized methodologies and guidance.
III. Commit to periodically report about the climate-related risks and opportunities (low-carbon transition and physical impacts) the organization faces and to validate the process internally.
IV. Appoint a member of the board or senior management with specific responsibility for climate related risks and opportunities, including policy, strategy and information.
V. Apart from building staff capacity, take measures to develop and enhance the board's and executive management's collective knowledge of and resources for climate risks and opportunities identification.
VI. Regularly conduct stakeholder consultations to identify and manage economic, environmental, and social risks (with climate risks and opportunities considered a subset of these). Relevant results are communicated to stakeholders (external and internal) in a transparent way.
VII. Develop and publicly communicate a climate-related strategy / policy and formulate climate-related targets.
VIII. Develop and put in place a process to assess climate-related risks and opportunities, including the use of multiple climate scenarios, for multiple timeframes to cover risks and opportunities. These assessments will include consideration of direct and indirect risks and opportunities, specifically those that may manifest themselves through the value chain. Risk management actions will systematically be identified for the priority climate-related risks and opportunities.
IX. Commit to disclose quantitative and qualitative information related to physical climate risks and opportunities using internationally recognized methodologies and guidance.
X. Implement regulatory measures for water fittings.
XI. Prepare plans for building capacity in each institution to effectively implement the sector NDCs including that of community water supply schemes.

XII. Awareness raising and behavioral change campaigns for the public towards sustainable use of water as a climate resilience building for water security.
XIII. Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities.
XIV. Review, update and prepare disaster management plans and emergency evacuation plans for buildings in flood-, landslide- or tsunami-prone areas.
XV. Creating and maintaining a database of NWSDB assets including water and sanitation infrastructure and buildings.
XVI. Improve data collection and forecasting capabilities.
XVII. Develop climate information services and early warning systems.
XVIII. Enhancing the implementation of Climate Resilient Water Safety Plan and Sanitation Safety plan
XIX. Good Stakeholder coordination for increase water use efficiency programme
XX. Increase QA/QC for new Projects
XXI. Catchment Protection Programmes and WQ surveillance
XXII. Research & Development studies and Piloting outcomes
XXIII. Energy Auditing/ Monitoring of Specific Energy Consumption (SEC) of All Water Supply Schemes
XXIV. Implement the CCIT development plan including the development of a database to track climate change related parameters and impact to water infrastructure and consumers to arrive in adaptation decisions. See the accompanying report on the CCIT development plan.

152. The proposals / recommendations mentioned above will need to be validated with NWSDB management before they can be acted upon. For example, NWSDB management may want to remove some of the proposals, add others, and modify some of the proposals. All such changes are welcome. Also, NWSDB management may go to set priorities in time for the various actions different from the proposals in this report.

153. When it comes to financing, NWSDB likely would want to include their cost estimates and reflect what financing is already secured from sources such as the government of Sri Lanka and international financial institutions (IFIs). Nevertheless, it is likely that a large amount of new financing will be needed to finance the proposed actions, as modified. A first estimate would be over $60 million for mitigation, over $400 million for adaptation, and $2 million for accompanying soft measures.

154. For various reasons it will be difficult to fill these financing requirements from traditional sources. Sri Lanka's macroeconomic financial situation is not very good, so that it will be difficult to attract financing from e.g. international financial institutions. Moreover, the adaptation investments will not lead to additional revenues that can be used to repay loans, while the mitigation investments mostly will result in either cost savings or revenues that are both in local currency, which does not help service loan nominated in hard currencies.

155. To address these issues, the report makes two recommendations that are elaborated upon in more detail in Section IX. The first is to secure a financing facility for which the commitments are spread out over time, so that each commitment by the government of Sri Lanka becomes smaller and is easier entered into. ADB's multi-tranche financing facility is such a financing facility. The second recommendation is to seek highly concessional GCF funding for the implementation of the CCRR. Approaching the GCF requires coordination within the government of Sri Lanka and identifying an interested Accredited Entity (AE), an entity recognized by the GCF as a valid intermediary. Section IX provides detailed suggestions for approaching potential AEs.

156. Finally, at the request of NWSDB, the potential for using carbon credits was explored. Table 17 and the accompanying text provide the main recommendations. Here we summarize Table 18 and include the accompanying text.

157. In principle, for any investment leading to GHG emission reductions, the mechanism for monetization of the carbon credits is in order of preference first Article 6.2, second Article 6.4, and third VCS or Gold Standard. The exception is emission reductions thanks to the reduction of technical water losses, for which the Sri Lanka Carbon Crediting Scheme is recommended.

158. When NWSDB decides to implement one or more of the proposed mitigation actions, the following steps are recommended if NWSDB wishes to gain revenues from the sale of carbon credits:

- Appoint a consultant with considerable carbon market experience to advise on whether entering the carbon credit development trajectory is advisable (market conditions change rapidly, so the current analysis may become outdated).
- Explore the recommended standards and update the recommended standard if appropriate.
- Where several standards are indicated, these are listed in order of priority to be explored. The general order of priority is Article 6.2, followed by Article 6.4, followed by voluntary market standards.
    - Currently Article 6.2 is operational, and several bilaterals are in the market for carbon credits under Article 6.2 (for example, Japan, Norway, Singapore, and Switzerland).
    - If a transaction under Article 6.2 cannot be identified, it makes sense to next explore Article 6.4. Article 6.4 is not yet operational; therefore two things will need to be checked on the Article 6.4 website[50] with priority: 1) Whether the multilateral mechanism has become operational; and 2) whether an approved methodology exists for the project type.
    - If both Article 6.2 and Article 6.4 are unavailable, next the international voluntary market standards are explored. For renewable energy the recommended standard is the GCC standard (VCS and GS do not apply to solar PV in Sri Lanka, with the exception of floating solar), while for energy efficiency VCS and Gold Standard are recommended as equal options.
    - It should be noted that at least in the case of VCS and Gold Standard, there are pathways to start a project under the VCS and Gold Standard and then move it later under the Article 6 mechanism.
- In the case of reduction in water losses leading to GHG mitigation, the recommendation is to use SLCCS if any carbon credit development is pursued. The reason for this recommendation is that the project is too small for the recognized international standard, combined with the difficulty of finding appropriate methodologies for the quantification of the emission reductions in line with the requirements of the standards.

159. To create the milestones for the proposed CCRR, the following steps are proposed:

- First, when approving the CCRR action plan, comprising the mitigation action, adaptation investments, and accompanying soft investments (as described above, with possible modifications), NWSDB also need to decide on the timing for the completion of the investments and other actions. This needs to take into account NWSDB priorities and commitments.
- From the completion time, calculate backwards when the actions need to be initiated (e.g., commencement of construction, start of capacity building activities). This creates a second milestone.

[50] https://unfccc.int/process-and-meetings/bodies/constituted-bodies/article-64-supervisory-body

- From these milestones for the initiation of the CCRR actions, it is possible to work backward to other action specific milestones, which capture the processes for the approval and implementation of investment and capacity building activities at NWSDB.
- These three steps define a series of milestones for the implementation of the CCRR, against which the progress in implementing the CCRR can be monitored.

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ANNEX 1. UPDATED DATA AND INFORMATION REQUEST

The following is the second update (dated 25 February 2023) of the data and information request formulated to assist the Greenhouse Gas Emission Accounting Specialist in the fulfillment of the assignment on behalf of NWSDB. It reflects all information received until 25 February 2023 as well as the comments on the draft inception report received on 22 February 2023.

Samples of water schemes and office buildings selected

A **sample of water schemes** was prepared based on number of connections, daily water production, and geographic spread. The sample is represented in **Table 1**. All information included is as received in the spreadsheet *Reply for CCRR request data.xlsx*.

Table 1. Selected water schemes.

Serial No.	Name of the water scheme	Region	Regional Support Center
28	Panadura	Panadura	Western South
41a[51]	Raddolugama	Gampaha	Western North
57	Kiriella	Rathnapura	Sabaragamuwa
71	Mawanella	Kegalle	Sabaragamuwa
78	Badulla	Bandarawella	Uva
103	Wellawaya	Monaragala	Uva
121	Mawathagama	Kurunagala	North Western
147	Gampola	Central South	Central
180	Medawachchiya	Anuradapura	North Central
199	Galle	Galle	Southern
273	Valaichchenai	Batticaloa	Eastern
285	Eachchlmp	Trincomalee	Eastern
294	Wadinagala	Ampara	Eastern
326	Mallavi	Mullaitivu	Northern
330	Vavuniya	Vavuniya[52]	Northern

The original intention was to draw a sample from a full list of buildings with accompanying information, to be provided by NWSDB. Until now, a summary list has been received, and full lists of some of the Regional Support Centers, but no full list covering all NWSDB office buildings that could serve as sampling frame. For that reason, an alternative approach has been followed, summarized below.

In this alternative approach, the **sample of office buildings** correspond to the two main[53] office buildings of the water schemes selected in the sample (see **Table 1**), plus the main office building of the regional support centers mentioned above and the NWSDB headquarters. This is reflected in **Table 2**. NWSDB is requested to provide a list of buildings according to the description above and the table below, including name of the building, address of the building, and building coordinates, and use this list throughout as the sample of office buildings. **The National Consultants will assist in the preparation of this list**.

Table 2. Selected office buildings

Two main office buildings from each water scheme mentioned below		One main office building for each entity	
Serial No.	**Name**	**RSC**	**NWSDB main offices**

[51] In the spreadsheet received, serial number 41 refers to two water schemes, Raddolugama and Katunayaka-Seeduwa. These two were relabeled 41a and 41b respectively. 41a, Raddolugama, was sampled for further data and information collection.
[52] Assumed. The region is not indicated in the spreadsheet reply received.
[53] Main in terms of number of people occupying the office building. In case there is only one office building in a water scheme, this single office building should be selected.

28	Panadura	Western South	HQ
41a[54]	Raddolugama	Western North	
57	Kiriella	Sabaragamuwa	
71	Mawanella	Uva	
78	Badulla	North Western	
103	Wellawaya	Central	
121	Mawathagama	North Central	
147	Gampola	Southern	
180	Medawachchiya	Eastern	
199	Galle	Northern	
273	Valaichchenai		
285	Eachchlmp		
294	Wadinagala		
326	Mallavi		
330	Vavuniya		

Data and information requested relating to NWSDB

1. **Maps for each of the sampled water schemes** (see **Table 1**) indicating all sources and storage facilities of water (wells, intakes, reservoirs, water towers), offices buildings and operational assets (water treatment plants, pumping stations, water pipelines, sewerage lines, wastewater treatment plants, others). For reservoirs, also information shall be provided on the surface area of the water reservoir.

2. **List of the sampled buildings** (see **Table 2**), including locations (coordinates) and altitude. Indicate the total floor area and average number of occupants during working days. **National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into the spreadsheet the already obtained information from some of the RSCs** to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

3. **Water balance for each of the sampled water schemes** (see **Table 1**), including sources, losses, uses and collection and treatment of wastewater

4. **For each of the sampled water schemes** (see **Table 1**), a **list** of operational assets (water treatment plants, pumping stations, water pipelines, sewerage lines, wastewater treatment plants, others), including locations (coordinates) and altitude.

5. For all equipment consuming fuels or electricity **in the sampled water schemes** (see **Table 1**) – details including the following:

- For electrical equipment: name of the equipment, purpose, capacity (MW), source of power (grid, generators, specific plant or self-owned renewable energy), hours of operation per year, amount of power consumed per year (MWh). See **Table 3**.
- For fuel consuming equipment (excluding vehicles): name of the equipment, purpose, capacity, fuel used, amount of fuel used per year. See **Table 4**.

National Consultants shall prepare two spreadsheet formats and shall insert (after checking for consistency and plausibility) into these spreadsheets the already obtained information to avoid asking for information already provided. The National Consultants shall share these spreadsheets with NWSDB to facilitate data collection according to a uniform format.

[54] In the spreadsheet received, serial number 41 refers to two water schemes, Raddolugama and Katunayaka-Seeduwa. These two were relabeled 41a and 41b respectively. 41a, Raddolugama, was sampled for further data and information collection.

6. For renewable energy generation sources **in the sampled water schemes** (see **Table 1**): Capacity, source, hours of operation per year, annual generation, amount of power that is consumed by NWSDB per year (MWh), any delivery back to the grid (MWh). See **Table 5**.
National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into this spreadsheet the already obtained information to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

7. **For each of the sampled water schemes** (see **Table 1**): Total amount of grid-supplied power consumed per year (last 5 year, in MWh), amount of self-supplied renewable power consumed per year (last 5 year, in MWh), fuel used (per fuel, annual consumption per year, last 5 year, excluding vehicles). See **Table 6**.
National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into this spreadsheet the already obtained information to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

8. **For each of the sampled buildings** (see **Table 2**): per building, a description of any insulation included (walls, roofs, doors, windows), description of lighting, description of internal climate control. See **Table 7**.
National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into this spreadsheet the already obtained information to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

9. **For pumps included in the sampled water schemes** (see **Table 1**): Description of water flow rate and head, energy source, annual hours of operation, rated power, and efficiency of the pump. See **Table 8**.
National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into this spreadsheet the already obtained information to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

10. **Per water treatment plant included in the sampled water schemes** (see **Table 1**): Water supply treatment technologies (per plant), including annual amount of water processed.
National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into this spreadsheet the already obtained information to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

11. **Per wastewater treatment plant included in the sampled water schemes** (see **Table 1**): Wastewater treatment technologies (per plant), including annual amount of wastewater processed.
National Consultants shall prepare a spreadsheet format and shall insert (after checking for consistency and plausibility) into this spreadsheet the already obtained information to avoid asking for information already provided. The National Consultants shall share this spreadsheet with NWSDB to facilitate data collection according to a uniform format.

12. Are there any reports and studies that have been carried out to identify climate related risks and opportunities to NWSDB? If yes, would it be possible to provide a **list** and **electronic copies**?

13. Are there any reports and studies that have been carried out during the last 10 year to identify greenhouse gas mitigation opportunities at NWSDB? If yes, would it be possible to provide a **list** of these reports and studies and provides **electronic copies** of the reports and studies?

14. Are there any investments that have been made during the last 10 year to increase the amount of renewable energy used, increase energy efficiency, reduce energy consumption, and/or mitigate greenhouse gas emissions at NWSDB? If yes, would it be possible to provide a **list** of such investments?

15. Are there any investments that have been made during the last 10 year to increase climate resilience at NWSDB? If yes, would it be possible to provide a **list** of such investments?

16. Have any studies been carried out by or on behalf of NWSDB during the last 10 years to identify capacity constraints to increasing climate resilience and mitigating greenhouse gas emissions? If yes, would it be possible to provide a **list** and **electronic copies**?

17. Have any capacity building or training activities been carried out during the last 10 years to increase the capacity of NWSDB to deal with physical climate change risks and to reduce greenhouse gas emissions? If yes, would it be possible to provide a **list** of such capacity building or training activities?

18. Describe the vehicle fleet, including the class (use classification in the NWSDB vehicle database) type (electric, hybrid, fuel powered), fuel used (if relevant, gasoline, diesel, LPG, CNG, biodiesel, …), estimated average distance per year (km), estimate of amount of fuel used. A spreadsheet was received, but is incomplete. In the spreadsheet additional information needs have been clarified. **National Consultants shall help NWSDB in completing the spreadsheet while inserting information received from some of the RSCs**.

Table 3. Details of electrical equipment of NWSDB (one table per water scheme, mention the name of the water scheme).

No.	Name	Purpose	Capacity (MW)	Power source	Annual operation (hr)	Annual power consumption (MWh)
1						
2						
3						
4						
5						
…						

Add rows as necessary. See spreadsheet template to be provided by National Consultants.

Table 4. Details of fuel using equipment of NWSDB (one table per water scheme, mention the name of the water scheme).

No.	Name	Purpose	Capacity (MW)	Fuel used	Unit (e.g. liter, kg…)	Annual fuel consumption (Defined Unit)
1						
2						
3						
4						
5						
…						

Add rows as necessary. See spreadsheet template to be provided by National Consultants.

Table 5. Details of renewable energy power generation equipment of NWSDB (one table per water scheme, mention the name of the water scheme).

No.	Name	Source (e.g. solar, wind, …)	Capacity (MW)	Annual hours of operation (hr)	NWSDB annual consumption (MWh)	Annual delivery to grid (MWh)
1						
2						
3						
4						
5						
…						

Add rows as necessary. See spreadsheet template to be provided by National Consultants.

Table 6. Total energy consumption by NWSDB, fuels and electricity (one table per water scheme, mention the name of the water scheme, exclude vehicles).

Year Energy type	2017[55]	2018	2019	2020	2021
Consumption of power supplied by the grid, MWh					
Consumption of self-supplied renewable power, MWh					
Fuel 1: … Measurement Unit: …					
Fuel 2: … Measurement Unit: …					
Fuel 3: … Measurement Unit: …					
Fuel 4: … Measurement Unit: …					

Add rows as necessary. See spreadsheet template to be provided by National Consultants.

Table 7. Description of key energy performance measures in NWSDB buildings (descriptive texts) (one table per building, mention the name of the building).

No.	Building name	Insulation				Lighting	Climate control
		Walls	Roof	Door	Windows		
1							
2							
3							
4							
5							
…							

Add rows as necessary. See spreadsheet template to be provided by National Consultants.

Table 8. Description of NWSDB pumps (one table per water scheme, mention the name of the water scheme).

No.	Pump	Energy source	Water flow	Head (m)	Annual	Rated power	Efficiency (%)

[55] Change years as needed. Purpose is to cover the last 5 years for which data are available.

	name	(power, diesel, …)	rate (m^3/s)		operation (hr)	(kW)	
1							
2							
3							
4							
5							
…							

Add rows as necessary. See spreadsheet template to be provided by National Consultants.

Please reply and send information to Mr. Thilina Pradeep, National Consultant, patprathnayaka@gmail.com and Mr. Casper Van der Tak, Greenhouse Gas Emission Accounting Specialist, info@nutawa.com. In case of large files, please use WeTransfer or similar file transfer tools.

ANNEX 2. CCG FRAMEWORK

The following provides for each of the CCG dimensions the key questions to be answered and the answers that correspond to a) basic level, b) intermediate, c) advanced and d) best practice.

1. Commitment

Which of the following statements best describes the status of your organizations's climate-related strategy, policy or targets (covering mitigation and adaptation aspects)?

a. We do not have a climate-related strategy, policy or targets.
b. We have some climate-related aspects reflected in our strategy, policy or targets.
c. We have a publicly communicated climate-related strategy or climate-related policy and climate-related targets in place.
d. We have a clearly defined and publicly available climate-related strategy, policy and targets together with performance measurement against the targets.

2. Accountability

Which of the following statements best describes your organization's structure for oversight or accountability of climate-related risks and opportunities?

a. Our board, management or operations team has no oversight or accountability of climate-related risks and opportunities.
b. A member of our board or senior management team has responsibility for environmental and social risks and opportunities, and there is accountability by management and operations. However, this does not explicitly cover climate risks and opportunities.
c. A member of our board or senior management has specific responsibility for climate related risks and opportunities, including policy, strategy and information.
d. In addition to option c., the organization provides incentives for the management of climate-related risks and opportunities, including the attainment of targets.

3. Processes

Which of the following statements best describes how your organization assesses climate-related risks and opportunities?

a. Our organization does not assess climate-related risks and opportunities facing the organization and its industry.
b. Our organization conducts ad hoc assessments of climate-related risks and opportunities, e.g. based on one timeframe with a focus on direct risks but does not have a process to assess on a regular basis climate-related risks and opportunities facing our organization or industry.
c. Our organization has a process in place to assess climate-related risks and opportunities, including the use of multiple climate scenarios, for multiple timeframes to cover risks and opportunities. The assessment includes consideration of direct and indirect risks and opportunities, specifically those that may manifest themselves through the value chain. Risk management actions have been identified for the priority climate-related risks and opportunities.
d. In addition to option c., the climate risk assessment process is integrated into the overall risk assessment process; both the risk and opportunity assessments are integrated into business planning and inform the business strategy, accompanied by a detailed Action Plan and regular monitoring. Overall, our company is taking risk management actions to

manage climate-related risks, e.g. internal carbon pricing, CAPEX or operational changes to reduce exposure to physical damage / disruption and has a process in place to regularly review their effectiveness.

4. Capacity

Which of the following statements best describes how your organization builds capacity to address climate-related issues?

a. Our organization does not have technical, financial or personnel resources allocated to the identification of climate change-related issues.
b. Our organization does have some technical, financial or personnel resources allocated to the identification of climate change-related issues and our organization secures capacity building/training on climate-related risks and opportunities on an ad hoc basis primarily dedicated to individuals in the environmental and social risk functions.
c. In addition to regular capacity building and training on climate-related risks and opportunities, our company takes measures to develop and enhance the board's and executive management's collective knowledge of and resources for climate risks and opportunities.
d. Within our organization, capacity in climate-related issues is developed in a structured manner, and executive management and staff at all levels of the organization have the expertise, experience and access to relevant resources required for their areas of accountability/responsibility.

5. Engagement

Which of the following statements best describes how your organization engages with stakeholders to support your activities regarding climate risks and opportunities?

a. We do not engage with stakeholders to support the work of our board and executive management around economic, environmental and social topics and their impacts, risks and opportunities.
b. Stakeholder consultation is used ad hoc to identify and manage economic, environmental, and social risks (with climate risks and opportunities considered a subset of these).
c. Stakeholder consultation is used regularly to identify and manage economic, environmental, and social risks (with climate risks and opportunities considered a subset of these). Relevant results are communicated to stakeholders (external and internal) in a transparent way.
d. Our organization participates actively in climate advocacy and stakeholder consultation that is dedicated specifically to climate risks and opportunities to support our board and executive management. Results are communicated to stakeholders in a transparent way with associated collaborative programs as required.

6. Disclosure

Disclosure is an area composed of three sub-areas, disclosure of GHG emissions, disclosure of low-carbon transition risks and opportunities and Disclosure of physical risks and opportunities.

6.1 Disclosure of GHG emissions

Which of the following statements best describes how your organization discloses information related to GHG emissions?

a. We do not disclose information related to GHG emissions externally.
b. We disclose information on our direct GHG emissions (Scope 1) and indirect GHG emissions from energy use (Scope 2) externally using internationally recognized methodologies and guidance.
c. We disclose information on our direct GHG emissions (Scope 1) and indirect GHG emissions from energy use (Scope 2) as well as some indirect GHG emissions from our value chain (Scope 3) externally using internationally recognized methodologies and guidance.
d. We disclose Scope 1 and 2 emissions as well as all Scope 3 emissions from our full value chain externally, including all upstream and downstream processes. Our disclosures are presented in a transparent and consistent manner, and in a decision-useful format.

6.2 Disclosure of low-carbon transition risks and opportunities

Which of the following statements best describes how your organization discloses information related to low-carbon transition risks and opportunities?

a. We do not disclose information related to low-carbon transition risks and opportunities.
b. We partially disclose information related to low-carbon transition climate risks and opportunities using internationally recognized methodologies and guidance.
c. We disclose quantitative and qualitative information related to low-carbon transition climate risks and opportunities using internationally recognized methodologies and guidance.
d. We present material low-carbon transition risks and relevant opportunities, including quantification of past and future impacts on our organization and implications for the long-term operation of our organization. The assessment clearly outlines uncertainties and assumptions, identifies interdependencies, barriers and how they will be addressed (referring to an accompanying Action Plan).

6.3 Disclosure of physical risks and opportunities

Which of the following statements best describes how your organization discloses information related to physical risks and opportunities?

a. We do not disclose information related to physical risks and opportunities.
b. We partially disclose information related to physical climate risks and opportunities using internationally recognized methodologies and guidance.
c. We disclose quantitative and qualitative information related to physical climate risks and opportunities using internationally recognized methodologies and guidance.
d. We present material physical risks and relevant opportunities, including quantification of past and future impacts on our organization and implications for the long-term operation of our organization. The assessment clearly outlines uncertainties and assumptions, identifies interdependencies, barriers and how they will be addressed (referring to an accompanying Action Plan).

7. Validation

Which of the following statements best describes the validation process in place for climate risks and opportunities in your company?

a. We do not have an internal process for validating the consistency and robustness of climate-related data, information and reporting processes.

b. We report about the consistency and robustness of climate-related risks and opportunities (low-carbon transition and physical impacts) and our process is validated internally.
c. We report about the consistency and robustness of climate-related risks and opportunities (low-carbon transition and physical impacts) and our process is validated by a third party.
d. Consistency and robustness of the climate risk and opportunity reporting data and processes are validated through third party assurance and the validation of climate-related data follows industry best practice and is at the same level of scrutiny as financial data.