TERMS OF REFERENCE

CONSULTANCY SERVICES TO ESTABLISH A HIGH AVAILABILITY SERVER CLUSTER FOR THE NATIONAL METEOROLOGICAL SERVICE OF BELIZE

1. BACKGROUND

1.01 The National Meteorological Service (NMS) of Belize currently operates five applications which are critical to the NMS daily operations as well as an early warning system. These are:

(a) Numerical Weather Prediction Model (NWP) for higher resolution over Belize. Locally run NWP takes inputs from a global weather model such as the Global Forecast System and downscales the results over Belize at a higher resolution.

(b) SURFACE Climate Data Management System (CDMS) – National CDMS for Belize which stores, processes, validates and disseminates data from weather stations across Belize.

(c) PLUVO – Application which ingests data from multiple weather and climate related sources for easy display so that alerts can be created and displayed. PLUVO currently ingests data from lightning detection network, radar, numerical weather predicting models and satellite observations.

(d) Website Information Management Platform – used by forecasters to update the NMS website with forecasts and alerts.

(e) Enhance mobile application and background processes.

1.02 These five applications serve as the backbone of the technological stack at the NMS and are highly automated, often communicating with each other to process and display data. As more and more stakeholders rely on the data processed by these applications the need for them to be continuously operational has become a top priority. Therefore, based on best information technology (IT) practices at this time, a Kubernetes/Proxmox cluster will be implemented within the NMS to deploy and maintain these applications. Both Kubernetes and Proxmox are open-source container orchestration systems for automating software deployment, scaling, and management, providing high available services with redundancy, load balancing and little to no down time. This will allow these critical services to be continuously operational and, in the event of application failure, to minimise downtime for redeploying applications.

1.03 To finance to exercise, the Government of Belize has secured funding from the Caribbean Development Bank to undertake the project entitled Multi-Hazard Impact-Based Forecast and Early Warning System for the Belize Watershed Project. The project is being

implemented between 2025 and 2026 with its expected outcome being improved institutional capacity of NMS and National Emergency Management Organization (NEMO) to deliver effectively early warnings and climate services. Key project outputs will include:

i. Current observation network, modelling and analysis tools upgraded.
ii. Risk analysis and hazard maps.
iii. Reliable and operational forecasting and warning system established.
iv. NMS and NEMO staff are equipped to effectively manage Early Warning Systems

2. OBJECTIVES

2.01 As noted above, the planned outcome of project under is 'improved institutional capacity of the NMS and the NEMO to effectively deliver early warnings and climate services.' More specially, the exercise falls under output 2, thus the specific objective is to ensure that current observation network, modelling and analysis tools have been updated. Via the exercise, at least four essential applications and tools will be optimally operating to meet the needs of the NMS and the country.

3. SCOPE OF WORK

3.01 The Consultant will be engaged to undertake the activities outlined below.

3.02 Activity 1: Inception Activities

(a) Convene an Inception Meeting with the NMS to discuss the overall exercise.
(b) Undertake a preliminary assessment of the various pertinent tools in operations at the NMS to obtain a better understanding of the assignment.
(c) Based on the above, prepare and submit an Inception Report which include, inter alia, details the methodology/ approach to the assignment and an updated work plan, and any anticipated challenges.

3.03 Activity 2: Kubernetes or Proxmox Cluster

(a) Initial assessment: The Consultant will conduct an initial assessment of the client's infrastructure, including hardware, network, and security requirements. This assessment should also consider future needs of the NMS. Based on this assessment, the consultant will submit a basic report on the advantages and disadvantages of using either Kubernetes or Proxmox. This will help to identify any potential challenges or constraints that may impact the project.
(b) Cluster design: The Consultant will design the Kubernetes/Proxmox cluster architecture based on best practices, taking into account the client's specific requirements, workload, and scalability needs. This will include the configuration of the master node and worker nodes, as well as the deployment of necessary add-ons and tools.
(c) Cluster setup and configuration: The Consultant will set up and configure the Kubernetes/Proxmox cluster on the four physical servers. This will involve

installing and configuring the necessary components, such as the Application Programming Interface (API) server, etc.

(d) Containerisation of Existing Applications: The Consultant will work with the client to identify and containerise the existing applications. This will involve creating Docker images files for each application and configuring them to run in a Kubernetes or Proxmox environment.

(e) Deployment: The Consultant will deploy the containerised applications to the Kubernetes or Proxmox cluster, ensuring that they are running smoothly and efficiently. This will involve creating Kubernetes or Proxmox deployment files, setting up pods, and configuring the necessary services and ingress.

(f) Testing and optimisation: The Consultant will conduct thorough testing of the Kubernetes or Proxmox cluster and the deployed applications to ensure that they are functioning as intended. Any issues or bottlenecks will be identified and addressed, and optimisations will be made to improve performance and scalability.

(g) Monitoring and Alerting: The Consultant will set up monitoring and alerting systems for the Kubernetes or Proxmox cluster, which will help to identify any issues or potential problems in real- time. This will involve configuring tools such as Prometheus, Grafana, and Alert manager to monitor the cluster's resource utilisation, uptime, and performance.

(h) Logging and Tracing: The Consultant will also set up logging and tracing systems to capture and analyse logs and events generated by the Kubernetes or Proxmox cluster and the containerised applications. This will help to troubleshoot issues and improve overall system performance.

(i) Disaster Recovery and Backup: The Consultant will work with the client to implement a disaster recovery and backup strategy for the Kubernetes or Proxmox cluster and the containerised applications. This will include regular backups of the data and configuration files, as well as setting up a disaster recovery plan in case of system failure or data loss.

(j) Web-Based Graphical Interface: The Consultant will also set up a web-based graphical dashboard to manage the Kubernetes or Proxmox cluster. The dashboard should provide an intuitive, user-friendly interface for the client's IT team to monitor and manage the cluster and containerised applications. The dashboard should provide the necessary authentication and authorisation mechanisms to secure the dashboard and restrict access to authorised users.

(k) Documentation and Knowledge Transfer: The Consultant will document the entire process of setting up the Kubernetes or Proxmox cluster and migrating the applications, including any custom configurations and settings. Knowledge transfer sessions will also be conducted to ensure that the client's IT team is equipped to manage and maintain the Kubernetes environment going forward.

3.04 Activity 3: Local NMS Numerical Weather Prediction (NWP) Model

(a) Based on assessment of NMS needs, install and configure a local NWP model that downscales from global models.

(b) Set up the model to generate hourly weather forecasts for the next 72h (3 days) at 3 kilometres (km) resolution and 3/3h forecasts for the next 168h (7 days) at 9 km resolution.

(c) Initialize the local NMS NWP model from a reliable global NWP model: Download and process data from global NWP forecasts to create the necessary input files to initialise the local NMS NWP model.

(d) Implement an appropriate data assimilation method to incorporate observations from the NMS weather station network, radar, and any available and reliable source of data.

(e) Set up the model to run twice a day: Use a scheduling service to automate the execution of WRF model to generate weather forecasts for 00Z and 12Z.

(f) Use appropriate visualization software to generate graphics from the model outputs that can be incorporated and displayed on the NMS website and mobile App ensuring that there is an appropriate method for forecasters to subjectively tweak these outputs to match observed conditions and to correct for any major and obvious model bias/error.

(g) Monitor and optimise performance: Use Kubernetes or Proxmox monitoring tools to monitor the performance of the WRF model and alert failures and delays. Use Kubernetes or Proxmox autoscaling to scale the cluster up or down based on the resource utilization of the WRF model and cluster workload.

(h) Provide a final report documenting setup technical details, results of the performance of the WRF model and any optimisations made during the project and provide training to NMS staff on the model use.

3.05 Activity 4: Enhance PLUVO

(a) Enable PLUVO support to Common Alerting Protocol (CAP) protocol: The existing system must be updated to support the CAP protocol to ensure that alerts are interoperable with other alerting systems and adhere to international standards for alerting.

(b) Add dynamic layers so that observed or forecasted hazards are overlayed to show possible impacts on vulnerable populations and critical infrastructure as well as evacuation routes and shelters.

(c) Alert creation and edition: The system must be extended to allow authorized external users from other organisations to create and edit their own alerts. This includes the ability to add and modify text, images, and other multimedia elements.

(d) Dissemination: The system must support the dissemination of alerts to relevant stakeholders, including emergency responders, government agencies, and the public. This includes the ability to send alerts via email, SMS, and social media.

(e) Tracking and reporting: The system must be able to track and report on the status of alerts, including the number of alerts sent, received, and acknowledged by stakeholders.

(f) Test the enhanced system to ensure that it is functional and meets the

requirements specified in the terms of reference.

(g) Provide technical documentation and training materials to enable the client to maintain and operate the enhanced system.

3.06 Activity 5: Migrate Applications to Cluster

(a) Development of a migration plan based on the analysis of the existing applications and their dependencies.

(b) Configuration of the Kubernetes or Proxmox cluster to support the automation of deployments of the applications via continuous integration and delivery (CI/CD).

(c) Modification of existing docker images and configuration files to create Kubernetes or Proxmox manifests that can be used to deploy the applications to the cluster.

(d) Deployment of the applications to the Kubernetes or Proxmox cluster and testing to ensure their correct functioning.

(e) Implementation of a monitoring and logging solution to detect and diagnose issues.

(f) Documentation of the migration process, including the configuration, deployment, and monitoring of the applications.

(g) Training of the client's IT team to operate and maintain the applications in the Kubernetes or Proxmox environment.

3.07 Activity 6: Enhance Mobile application and background processes

(a) Update and enhance the NMS mobile app developed by the Resilient Rural Belize to include features developed through outputs 2 and 3.

(b) Train staff in the NMS' staff in the usability of app.

4. REPORTING REQUIREMENTS AND DELIVERABLES

Deliverable	**Expected Timeline**	**Payment schedule**
1. Inception report: should include a detailed methodology to be used for installation and configuration of applications and responsibility of team members.	Two (2) weeks after commencement of the assignment	6%
2. Report on the full deployment and configuration of the Kubernetes or Proxmox Cluster	Two (2) months after commencement of the assignment	8%
3. Report on Deployment of Numerical Weather Prediction (NWP) over Belize under the Weather and Research Forecasting (WRF) model	Two (2) months after commencement of the assignment	16%
4. Report on enhancement of PLUVO	Five (5) months after commencement of the	28%

	assignment	
5. Report documenting completed migration of applications to Kubernetes or Proxmox cluster	Six (6) months after commencement of the assignment	8%
6. Report on training provided	Seven (7) months after commencement of the assignment	6%
7. Report on updated NMS App	Eight (8) months after commencement of the assignment	28%

4.01 All deliverables are to be submitted to the Project Coordinator via email in both Microsoft Word and PDF versions.

5. QUALIFICATIONS AND EXPERIENCE

FIRM

5.01 Execution of this Terms of References requires a consulting firm having requisite capacities. The successful firm is required to possess the below listed competency for the successful execution of this assignment.

General experience:

(a) The firm should have successfully completed a minimum of five (5) projects pertaining to web applications used for weather and climate data analysis during the past 10 years.

Specific and Regional Experience

(a) Demonstrated capacity and experience of having configured at least two (2) NWP models that can simulate atmospheric phenomena at different scales and resolutions.

(b) At least three (3) projects delivering data processing and analytical services for National Meteorological Services in the Caribbean or Central America successfully completed.

(c) Demonstrated evidence of project management and coordination capacities to undertake the assignment in view of other commitments.

KEY EXPERTS

1.02 Key Expert 1 – Team Leader and Expert in Web Application Software Development

- Qualification: Bachelors Degree in Computer Science specializing in web application development and programming languages
- Experience and other skills:

- At least 5 years of experience developing mobile applications using cross platform programming languages and APIs
- Proficiency in programming languages for Mobile app development such as, React Native, Flutter, Typescript as evidenced by industry certification or completion of at least two similar assignments.
- Excellent management skills, as demonstrated by having led at least two related assignments and being familiar with the use of agile software practices.

The Consultant is responsible for presenting a complete team in accordance with the Terms of Reference (ToR). In addition to the Lead Consultant, the team must include specialised members, including but not limited to those listed below.

1.03 Expert 2 - Expert in Server cluster management

- Qualifications:
  - Possession of a recognised Bachelor's Degree in Computer Science, Computer Information Systems, Management Information Systems, Computer Engineering, Information Technology or a related area.
- Experience and other skills:
  - At least 5 years of experience managing on prem and cloud server clusters.
  - At least 5 years of experience managing physical servers as a cluster, using orchestration software and type I hypervisors.
  - Proven experience of having managed the deployment of containers and VMs across multiple servers in a redundant manner for at least two similar assignments.

1.04 Expert 3 - Expert in Developing local/regional NWP models

- Qualifications:
  - Minimum of a Bachelor’s Degree in Meteorology, Atmospheric Science or a related field along with specialization in computer science and numerical weather prediction.
- Experience and other skills:
  - At least 5 years of experience installing and operating regional numerical weather predictions models, including performing data assimilation.
  - Fully versed in programming languages used in Numerical Weather Prediction such as Fortran, C++, and Python as evidenced by appropriate certification.
  - Fully verse in using diverse software and tools to create a range of graphics to visualize NWP outputs as evidenced by appropriate certification.

1.05 Expert 4 - Web Application Developer

- Qualification:
  - Bachelors Degree in Computer Science specializing in web application development and programming languages
- Experience and other skills:

- Minimum of 10 years' experience working with full stack, big data web applications and Dev-Ops tools such as: Django/Python, Apache Airflow, PostgreSQL, PostGIS, TimescaleDB, VueJS, JavaScript, Ajax, Docker, Git, Ansible, and Linux.
- Proficiency in Front-End Development using JavaScript and related frameworks and Backend Development with Django and PostgreSQL data management as evidence by completion of at least two related assignments and/or relevant certification.
- Proficiency in web application deployment using virtual environment and Linux administration as evidence by completion of at least two related assignments and/or relevant certification.

2. DURATION

2.01 The duration of the consultancy services is expected to be approximately 250 professional days over an eight (8) month period.

3. LANGUAGE

3.01 All reports and other deliverables produced under this assignment shall be in English.

4. ADMINISTRATIVE INFORMATION

4.01 Contracting authority: The contract will be issued by the Ministry of Economic Transformation, Belize on behalf of the National Meteorological Service of Belize.

5. LOCATION

5.01 The assignment will be undertaken in Belize; however, it is envisioned that all aspects of the assignment outline in this TOR can be undertaken remotely.

5.02 the consultant will liaise directly with the Project Coordinator, who is based at the NMS.