

CONTRACT FOR THE ASSIGNMENT OF TECHNICAL-SCIENTIFIC CONSULTANCY SERVICES REGARDING THE ACQUISITION OF HYDROGEOLOGICAL DATA OF LAGOS AQUIFER SYSTEM

The University of Padua - Department of Civil, Environmental and Architectural Engineering (hereinafter “Lead Partner”), with registered office in Padova, Via Marzolo 9, Tax Code 80006480281 - VAT no. 00742430283, in the person of Prof. Andrea Giordano, as Head of the Department, authorised to enter into this contract by resolution of the Department Board of 14 July 2022

ASSIGNES TO

Observatory Earth Analytics Consults (hereinafter “Contractor”), with registered office in Lagos, Nigeria, VAT f no. 21068645-0001, phone +2347079681949, in the person of Dr. Joseph Aro, as Co-founder/ Chief Data & Analytics Officer

Whereas

- a) The Lead Partner, has signed on 5 July 2022 the Research Partnership Agreement no.RE 726-2022 CZZ3340 with the Agence Française de Développement, (hereinafter “AFD”), 5 Rue Roland-Barthes, 75012 Paris, entitled “ENGULF - Coastal land subsidENCE in the GULF of Guinea: Assessing relative sea-level rise and land subsidence of coastal mega-cities and river deltas along the Gulf of Guinea” (hereinafter “Project”). Annex 1 provide a summary of the ENGULF Project;
- b) this Project requires the collection of hydrogeological data of the aquifer system of Lagos, Nigeria, to complete the activities of WP2;
- c) the Contractor has been selected by the Lead Partner and AFD based on the specific knowledge in the field of data acquisition, specifically in relation to Earth observation, and has the personnel, expertise and specific knowledge that are necessary for the performance of the activities as reported in the ToR below.

Terms of reference for data collection

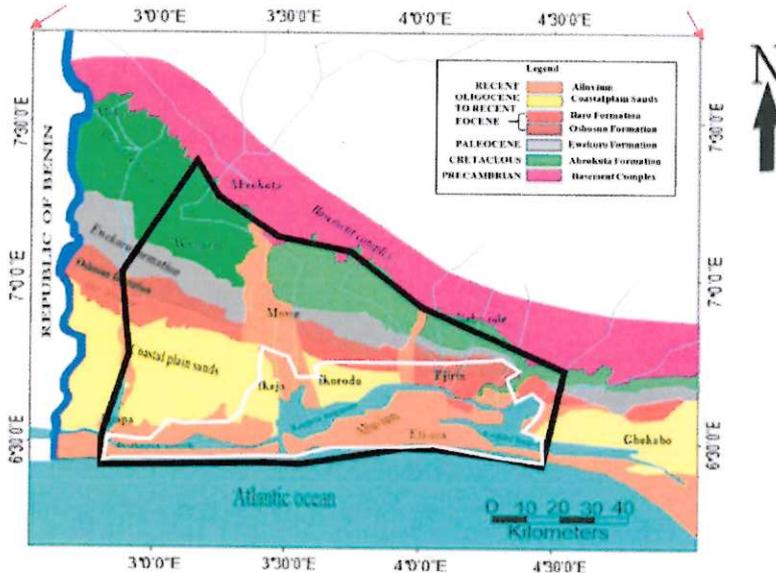
1. Objectives

The present contract aims at collecting all relevant data, as described in the next section, in order to build a numerical model of subsidence for Lagos.

2. Data of interest

Geological map of Lagos coastland showing the area of interest for WP2: the white line represents the portion within the Lagos State, the black line is extended to the north and hydrogeologic information on

this wider zone should be of interest too in order to develop a “regional” numerical model of the aquifer system.



The data of interest are divided in three main groups (prioritized from 1 - most important to have as soon as possible - to 3 - less important to have soon):

1) Data related to the hydrogeologic structure of the subsurface:

- lithostratigraphic boreholes (shallow and deep) of the alluvial (Quaternary) deposits;
- VES, ERT and seismic sections;
- cone penetration tests;
- maps and vertical sections of the aquifer system and of the bedrock depth;

2) Data related to hydro-geomechanical properties of the deposits:

- in-situ pumping tests, Lefranc tests;
- classical geotechnical characterization of soil samples: grain-size distribution, oedometric tests, specific weight, permeability tests, etc. These data are always needed to plan structures and infrastructures. Associated to this info it should be important to retrieve elevation data acquired during the built-up of structures (buildings) and infrastructures (coastal jetties, harbors, bridges, roads).

3) Data related to groundwater withdrawals and aquifer conditions (over the last 20 years):

- main well-fields (used to supply water to the city and industrial needs): location, year of realization, number of wells, withdrawal rates over time (on a monthly basis);
- estimates about the (density) distribution of private (shallow) wells and the groundwater pumping rates (monthly or yearly estimates);
- piezometric levels (on a monthly to yearly basis).

3. Methodology and Data collection plan

A multi-faceted approach will be employed to achieve the research goals. This includes:

- Collaborating with private companies and government agencies to access geotechnical data.
- Employing advanced data analysis tools and techniques.

- Validating data through field visits and geospatial analysis.

The strategy for data collection involves:

- Establishing partnerships with private geotechnical firms and relevant governmental agencies.
- Gaining access to proprietary and publicly available data.
- Ensuring data integrity through rigorous quality control measures.

Potential data sources:

Dataset	Potential sources	Specifics	comments
Lithostratigraphic Boreholes (Shallow and Deep) of Alluvial (Quaternary) Deposits	Nigerian Geological Survey Agency (NGSA)		
	Academic institutions	(Unilag) (LASU) Unibadan OAU	UNILAG and LASU have already been contacted during the 1 st year of the ENGULF project, but no data were provided. It does not seem relevant to contact them again (if no direct and relevant contacts are already available).
	Oil and Gas Companies		
VES, ERT, and Seismic Sections	Office of the Surveyor General		
	Nigerian Geological Survey Agency (NGSA)		
Cone Penetration Tests	Engineering Firms	ERSC Others	
	Engineering Firms	Royal Haskoning Ecoplanet Joshtob Vanord	
	Government Agencies	NPA NN Hydrographic Office	

4. Timeschedule and Deliverables

The project will span 10 weeks with the following key milestones:

Data Sourcing	3 Weeks
Data Collection and Collation	5 Weeks
Reporting	2 Week

Note: Timelines for sourcing and Data collection would run concurrently

Deliverables:

- **Regular online progress meetings:** the service provider will present the work progress to the principal investigators of the project (Pietro Teatini, Philip Minderhoud and Marie-Noëlle Woillez) through an online meeting every two weeks. On this occasion, he will present the list of institutions/firms contacted and results obtained (quantity and type of data). A PPT will be provided to support the presentation.
- **A structured data base** (all data will be stored on in a GoogleDrive space provided by the principal investigators). The data collected will be provided in digitized format.
- **A comprehensive research report.** The report should include:
 - Map(s) showing the data locations, with depths and type of data available;
 - A complete description of data collected;
 - A structured digital supplement (e.g., a GIS project) of all data collected so far with a direction guide of where to find which data, and any important meta data – data source, data ownership, any restriction to its use etc.
 - An assessment of data quality and reliability;
 - An assessment of actions taken for data collection.

5. Budget

The budget for the service provider is as follows:

1850	€1850
Travel and Transportation x 2	€470
Reporting and Communication	€470
Miscellaneous	€470
Total	€3260,00

Additional budget will be dedicated to data acquisition from institutions and firms when necessary. The maximum amount is set to **€4650,00**. Any data purchase or financial compensation to the firms/institutes (e.g. for data sorting) will be discussed and validated with the principle investigators. The amount will be reimbursed to the service provider on presentation of invoices.

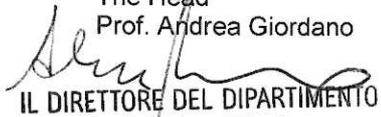
6. Payment

The payments for the service provider will be made to:

Account Name: Joseph Aro
Banking Institution: Canadian Imperial Bank of Commerce
Bank Physical Address: 20069 - 64th Avenue Langley, BC V2Y1M9
Account Number: 007209642137
Account Currency: USD
Bank SWIFT: CIBCCATT
Bank Sortcode: 010
Intermediary Bank SWIFT: PNBUS3NNYC
Intermediary Banking Institution: Wells Fargo Bank N.A.
Intermediary Bank Address: New York, NY, US
Intermediary Bank Routing Code: 026005092

Padua, 04/04/2024

University of Padua
Dept. ICEA
The Head
Prof. Andrea Giordano


IL DIRETTORE DEL DIPARTIMENTO
Prof. Andrea Giordano

Observatory Earth Analytics Consults
Co-founder
Dr. Joseph Aro



ANNEX 1 - General presentation of the ENGULF project

a. Context

The coastline of the Gulf of Guinea is lowly elevated and particularly vulnerable to erosion and sea level rise. Many capital cities are located at the coast, including megacities with millions of inhabitants such as Lagos, Abidjan and Accra. Population projections for these cities suggest a further staggering increase in the coming decades. Also, many of the countries economic activities are located along the coastline. For example, in Nigeria coastal areas are home to 85% of industry (mainly activities related to oil and gas extraction) and more than 100 million people.

The entire coastline is currently experiencing alarming coastal erosion rates, ranging from 1 to 15 m/year between Côte d'Ivoire and Nigeria. The main causes of these phenomena are generally linked to human activities: sand extraction, decrease in sedimentary input from rivers due to upstream dams, port developments or even coastal protection structures that accentuate erosion downstream. As a result, the problem is well studied and various programs aim to put in place coastal protection measures.

On the other hand, studies of impacts and vulnerability to sea-level rise in the context of climate change appear to be more limited. One can find in the literature various studies conducted on a very local scale or sub-regional. There are also some global impact studies that give orders of magnitude on the risks of submersion for the Gulf of Guinea coastline. Recent advances in elevation data (especially the availability of new satellite Lidar data) provide exciting opportunities to improve the elevation estimates of the region, which have been investigated by an AFD-funded scoping study executed by the University of Padua (UNIPD), Wageningen University (WU), in collaboration with Universities of Ghana and Lagos. Results of this study have been published in 2023 in 3 AFD research papers¹.

Recent research shows that while sea level is rising as a result of global warming, the majority (51-70%) of the present-day *relative* sea-level rise (SLR) experienced by people worldwide is actually caused by land and coastal city sinking, i.e. land subsidence. Globally coastal land subsidence is critically under-quantified, and the Gulf of Guinea region is no exception to this. This underlines the importance of besides considering climate change-driven sea-level rise also to include the land component as well and assess the complete effect of relative sea-level rise.

b. Objectives

The ENGULF project aims to fill this lacune in knowledge on coastal land subsidence and relative sea-level rise along the Gulf of Guinea through applying a combination of advanced techniques involving recent satellite measurements of vertical land movement (using PS-InSAR), multi-disciplinary hydrogeological data analysis, and data-driven numerical modelling. It will provide useful space-borne quantifications of current coastal subsidence rates (i.e. maps showing subsidence rates), assess the driving forces of land subsidence and provide first projections of potential future subsidence using models.

¹ <https://www.afd.fr/en/ressources/scoping-review-vulnerability-nigerias-coastland-sea-level-rise-and-contribution-land-subsidence>

<https://www.afd.fr/en/ressources/scoping-study-coastal-vulnerability-relative-sealevel-rise-gulf-guinea-coastal-elevation-assessment-and-literature-review>

<https://www.afd.fr/en/ressources/vulnerability-ghanas-coast-relative-sea-level-rise-scoping-review>

At various stages of the project new information and data on relative SLR will be generated. New quantifications of subsidence and relative SLR will provide immediate valuable information for policymakers and coastal (infrastructural) development projects potentially impacted by relative SLR. Impact will further be created by collaborating with local institutes, connecting to other projects (e.g. WACA-VAR programme) and disseminating findings, data and tools to local stakeholders (policymakers, NGO's).

One of the long-term objectives is to use this project to create awareness and agenda setting of the issues of coastal land subsidence and relative SLR in the Gulf of Guinea region. Avoiding advent of a new "Jakarta case" along the Africa coast is paramount. This project aims to provide first estimates of potentially large and currently unforeseen impacts, as well as to provide valuable insights to support sustainable development projects and policymaking in the region. The project will focus on intensive collaboration between international and regional experts, both to deliver concretely to the project deliverables and to share knowledge and build capacity in the region. It aims to create and foster a Community of interest of local experts in the region (with the support of UNESCO LASII) and provides inputs for follow-up research and applied science projects well beyond project's outputs.

c. Areas of interest:

ENGULF focuses on the countries situated at the Gulf of Guinea, ranging from Ivory Coast to Nigeria. See following figure for the geographical extend of the areas of interest.



The biggest city of Nigeria, Lagos, has been selected as the first case for which a full assessment will be performed, from monitoring subsidence towards process-based numerical modelling. Indeed, we can make use of new (unpublished) InSAR-based estimates of vertical land motion already available for Lagos at Virginia Tech (USA). In addition, Lagos State, through its Ministry of the Environment has officially expressed a strong interest for the project and their wish to collaborate. Therefore, ENGULF focuses on the interpretation of the measurements, investigate process relations, and start building the required database to support the construction of a 3D numerical subsurface model for this city. The objective is to develop the entire multi-disciplinary approach for Lagos as a showcase for the region (much like the subsidence research in the Mekong delta acts as a showcase for a successful approach in Asia).

d. Workpackages overview

The ENGULF project includes 4 different workpackages (WPs), as summarized in the table below:

WP 1 regional subsidence assessment and rSLR projections	WP 2 Focus Lagos	WP 3 Focus on other hotspots	WP 4 community of interest and diffusion
<p>Perform new InSAR analyses for the whole coastline for the Gulf of Guinea (from Ivory Coast to Nigeria), for the low elevation coastal areas to assess current subsidence rates</p> <p>provide first preliminary projections (maps) of future RSLR and assess exposure of population, economic activities or ecosystems</p>	<p>In-depth analysis of subsidence</p> <p>Building a numerical model</p> <p>New projections of rSLR</p>	<p>advanced interpretation of measured subsidence</p> <p>Data collection for future modelling work</p>	<p>Building of a Subsidence Community Of Interest (COI) involving local researchers</p> <p>Workshops and seminars</p> <p>First West African Coastal Area Regional Workshop on Coastal Land Subsidence: (tentative: Fall 2024 in Ghana)</p> <p>Summaries for policy makers/policy briefs</p>

e. Activities within WP2 (Lagos case)

Within ENGULF, WP2 focuses on the Lagos case. InSAR data analysis published in the literature and additional analysis performed within the framework of WP1 of ENGULF show that parts of the city have high subsidence rates, up to more than 8 mm/year. Lagos might have the potential to face increased subsidence rates in future decades, especially if water accessed is developed based on groundwater extractions.

Therefore, WP2 has the general objective to perform in-depth analysis of subsidence in Lagos and surroundings, to understand the drivers and processes. The analysis includes the building of a numerical model of land subsidence in Lagos and perform process-based projections of subsidence according to different scenarios. However, building such a model relies on availability and access to ground-surface (elevation, subsidence) and subsurface data (geology, hydrogeology, geomechanics).