



Work shop Report

Land Subsidence in the Coastal Zone of Central Java

Closing Workshop, December 15th, 2022

Land Subsidence in the Coastal Zone of Central Java

Closing Workshop



Thursday
15 December

Hybrid event
8.00 -16.30h
Waktu Indonesia Barat (WIB)



Netherlands Enterprise Agency



Deltares

Work shop Report

Land Subsidence in the Coastal Zone of Central Java

Bilateral cooperation in water Indonesia – the Netherlands and land subsidence

The bilateral cooperation between Indonesia and the Netherlands in the field of water (formally registered under the MoU Water, 2021-2026) provided the formal framework for the specific technical studies and cooperation on land subsidence in Central Java. The December 15, 2022 Workshop formed an intermediate moment to take stock of the cooperation results.

Kota Semarang and the coastal regencies of Pekalongan and Demak experience high land subsidence rates, mostly caused by unsustainable groundwater abstractions. Groundwater is needed to meet water demands amongst others from industry, agriculture and residents. Unravelling the precise patterns and trends and various causes of subsidence and the impact on the North coast of Java is needed to take effective measures in the affected areas.

Over the past 1.5 years, Indonesia and the Netherlands have joined forces in the study 'Towards solution-oriented technical cooperation on Land Subsidence, North Coast, Java' to gain a better understanding of the causes of land subsidence and the impact. In the attached document the latest insights and the results of the study are shared.

First, in 2020-2021, a high resolution and accurate InSAR based ground deformation survey was conducted in the areas that were considered most vulnerable and relevant. (See Figure 1). In particular the Pekalongan city region was known to experience significant land subsidence, causing frequent and widespread flooding and inundation by high tides (rob). Furthermore, the land subsidence in the central parts of Semarang city, and in particular the eastern coastal zone was mapped.

The data set can be viewed in an on-line viewer, provided by the company Sensar: [20210021 - RVO Central Java - Interactive Web Map \(sensar.nl\)](https://sensar.nl/20210021-RVO-Central-Java-Interactive-Web-Map). A password to access the data can be requested to rien.dam@outlook.com:

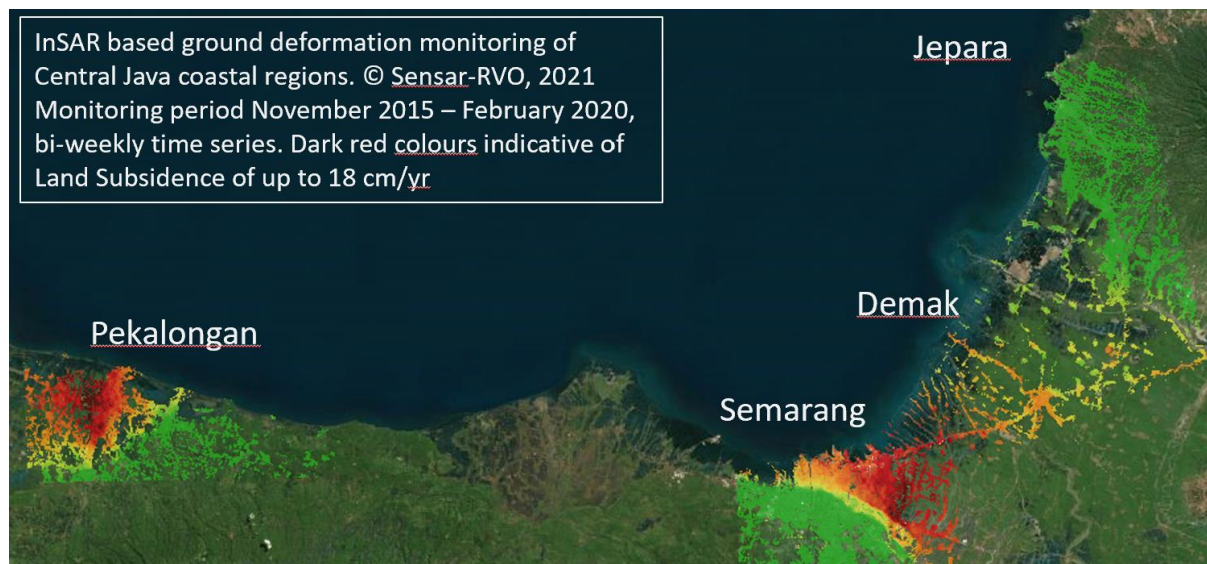


Figure 1: InSAR based ground deformation monitoring of Central Java coastal regions. © Sensar-RVO, 2021. For a detailed analysis of these monitoring data, see the underlying report.

In eastern Semarang, extending into Demak Regency, in the coastal zone, severe land subsidence exacerbates rob inundations, and nearly continuous submergence of coastal villages (viz. Sayung, Timbulsloko and other coastal villages).

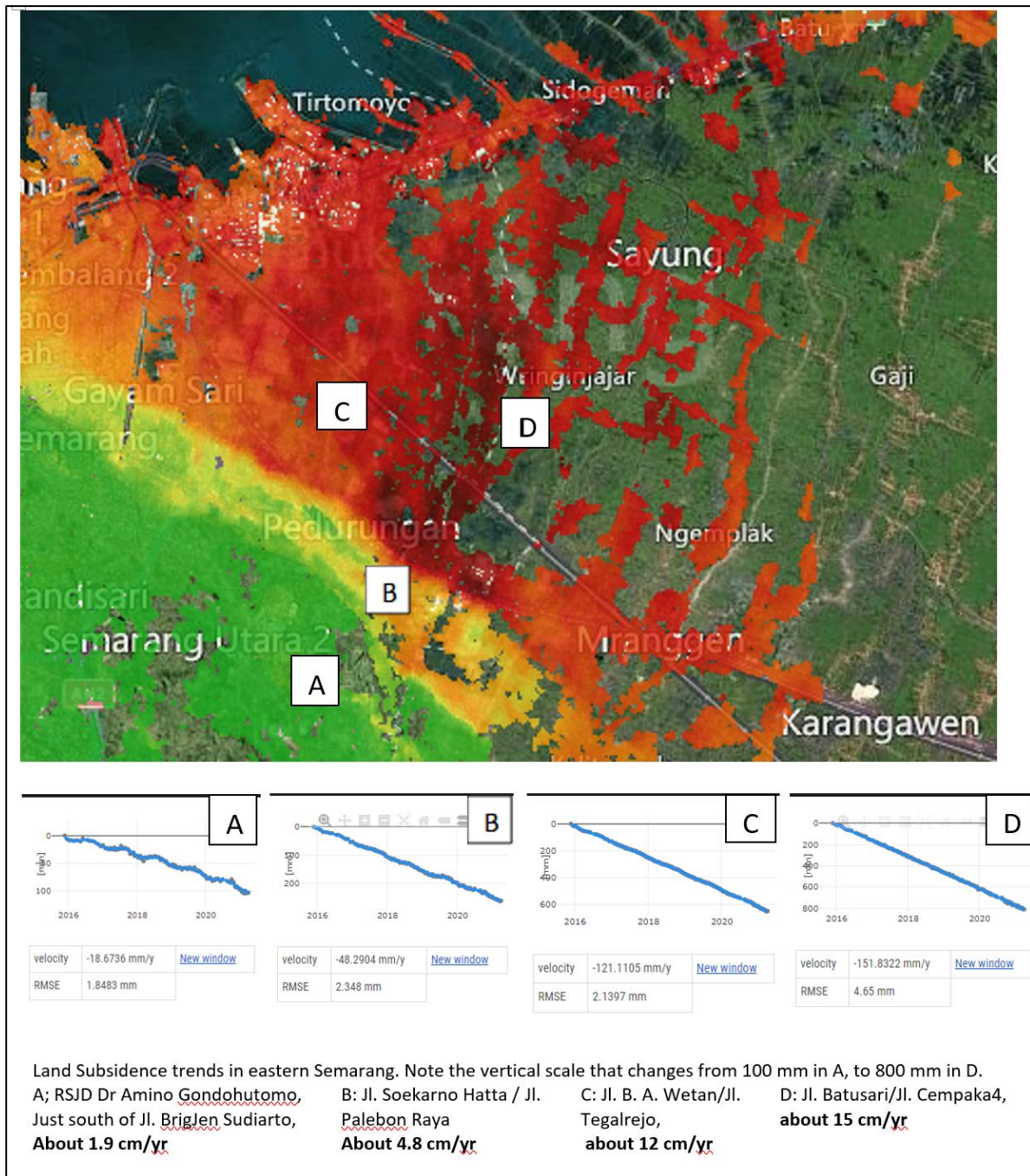


Figure 2: This is an overview of the Land Subsidence (LS) for the eastern part of Semarang. Indicative LS rates for specific locations can be obtained from the data set. The four graphs show some typical LS rates in the different colour zones (note the changing vertical scale of the small graphs).

In Pekalongan the situation is almost as severe; Figure 3 depicts the most affected area and shows some typical subsidence rates. Over the observed period of about 5 years some areas have subsided by over 80 cm.

The InSAR data set provides very strong, spatially and temporally consistent data on the land subsidence processes during the monitored period (end of 2015 – early 2020, just over 5 years). It is also a strong analytical tool to assist with understanding the underlying causes of the subsidence; by zooming in on specific locations, a spatially detailed analysis can be made. Also, since the data set consists of a large number of bi-weekly measurements, also the land subsidence trends over time can be analyzed.

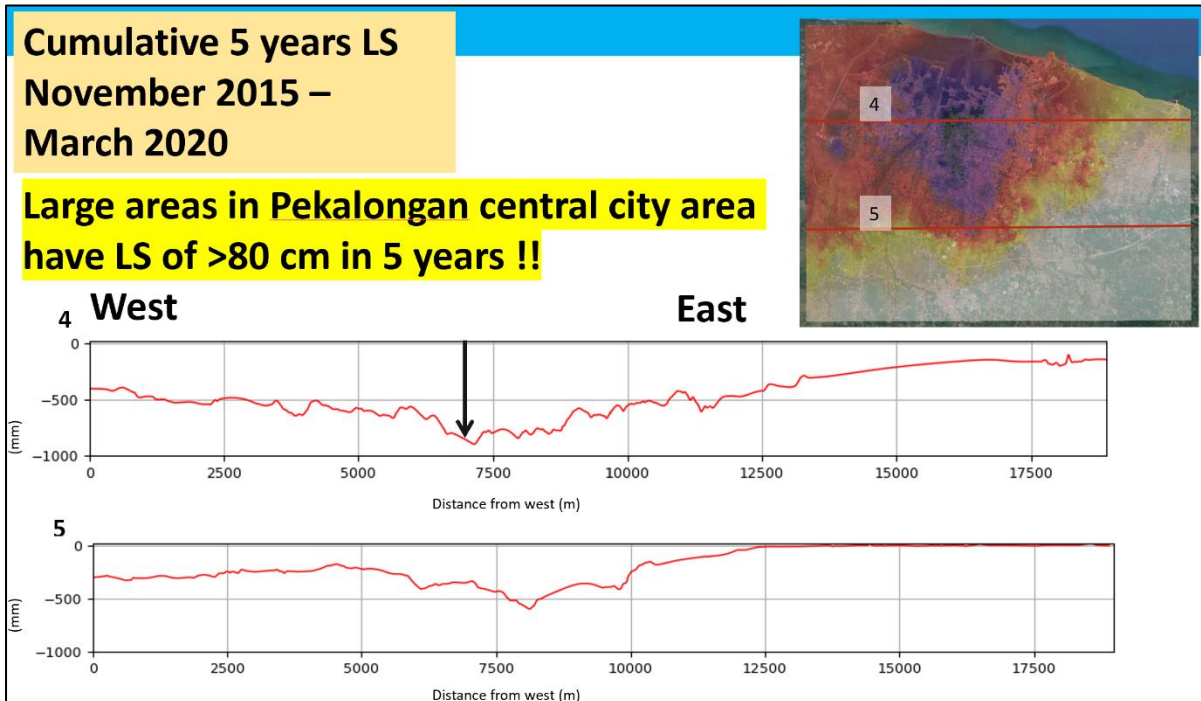


Figure 3: Spatially integrated land subsidence data. The central – eastern Pekalongan city area, built on relatively soft (unconsolidated) marine coastal deposits, and with a concentration of groundwater extraction wells, consistently shows severe land subsidence.

The data set was used in two subsequent studies.

1. Wageningen University (Netherlands) MSC student Mr Thaem Mous used the data set for his MSc thesis field research: "*Analysis on the spatial and temporal variation of land subsidence in the coastal city of Pekalongan, Indonesia*". The essential results of this Master thesis are presented in the attached presentation.
2. A study by Deltares, the Netherlands. The Deltares team conducted the technical study "*Towards solution-oriented technical cooperation on Land Subsidence, North Coast, Java*". This study was completed in December 2022. The final report of this study is available on request and some key results are presented in the document below.

The above-mentioned documents are just a few of a variety of mostly research related reports on land subsidence in the coastal zone of Central Java. It is critically important this work is well documented and disseminated as widely as possible, this concerns both the analytical (interpreted) results, as well as the primary (monitoring) data that these studies have generated.

Therefore, it was considered important to prepare the underlying document. The bilateral cooperation between Indonesia and the Netherlands in the field of water (formally registered under the MoU Water, 2021-2026) provided the formal framework for the specific technical studies and cooperation on land subsidence in Central Java.

The December 15, 2022 Workshop formed an intermediate moment to take stock of the cooperation results.

The results that were presented on December 15, 2022 for an on-line and off-line audience of some 60 participants mostly speak for themselves. Some interesting issues stand out and justify a short observational comment.

1. It was good to see that the implementers of the various studies have been able to intensively use the available InSAR data set, and untangling the spatial and temporal trends and patterns. It is evident that land subsidence is highly variable from place to place and over different periods of time; it was made clear that this is caused by the underlying root causes of the land subsidence physical process; 1) a different build-up of the subsoil, with at places susceptible, soft sediments; 2) a complex interaction between the subsoil compaction process and depleting groundwater levels due to, most likely, overextraction; 3) a quick land subsidence response to changing land use. The data also seem to suggest seasonal variations.
2. As several presenters have pointed out, dealing with land subsidence is not just a (geo)technical issue, but one that requires dedicated and quality expertise on governance and societal-human behavioral aspects. A strong interdisciplinary approach is needed, firstly to understand the underlying processes and their impact on society, and secondly to come to mitigation and remedial measures that will be adopted and acceptable for the involved communities and governance stakeholders.
3. The issue of land subsidence – in a context of sustainable coastal zone management and disaster mitigation - clearly begins with sound and intensive monitoring and data collection as a basis. But as a slow-moving, “hidden” process, it undisputedly should be considered in a context of “...systematic disaster management...” (the words of Dr. Andreas) and taken very seriously. As is pointed out and becomes very painfully clear time and again in Pekalongan, Semarang and coastal Demak, the areas strongly affected by land subsidence experience very disturbing and disastrous (rob) floods. Priority budgetary, technical and human resources must be committed to deal with the issues.
4. On the basis of multiple studies in various locations worldwide it has been firmly established that the exceptional land subsidence rates observed are primarily caused by falling groundwater levels and decreasing groundwater pressures in the uppermost tens of meters of the subsoil (usually correlating with a sequence of unconsolidated coastal (fluvial and nearshore marine) clayey and sandy sediments. The coastal zone of Central Java is no exception; major segments of the coastal stretch between Brebes and Jepara (not everywhere !) are quite vulnerable to land subsidence due to the combination of intensive groundwater extraction and the presence of soft subsoil sediments. It was the ambition of this technical cooperation to study and clarify this relationship between groundwater and extreme land subsidence, in order to develop effective mitigation measures. Proper insight in the regional/local groundwater dynamics is critical for this.

Unfortunately, it had to be concluded that there is a structural lack of good groundwater monitoring data and insufficient understanding of the coastal groundwater systems that form the basis for this insight. Monthly to quarterly groundwater level monitoring data for a sufficient number of wells (1-3, or more per 1 square km), over extended periods, would be a good start. This kind of data is required in order to be able to develop groundwater use guidelines that: 1) allow for a sensible and sustainable exploitation of this valuable resource, and 2) take

account of land subsidence vulnerabilities in a location specific manner. It is recommended to consider these approaches in a future activity in Pekalongan and eastern Semarang. In the underlying document several ideas are elaborated on groundwater management and conjunctive surface- and groundwater use; it is worthwhile to consider these for future cooperation.

The above four observations are just some of the insights that were acquired in the course of the small cooperation project with limited duration and modest resources. The project was supported by funds made available by the Netherlands Government, under the Indonesia-Netherlands bilateral cooperation in water.

It is hoped that the initiated collaboration with the technical agencies of the Ministry of Public Works and Housing (viz. Balai Air Tanah, BBWS Pemali-Juana) and with the National Task Force on Land Subsidence, chaired by the Coordinating Ministry for Maritime and Investments Affairs can be continued. The Task Force and MPWH partners are sincerely thanked for the support to disseminate this report.

In case of further questions please find contact details below.

Dr. Rien Dam

Netherlands Delegated Representative Water for Indonesia, Jakarta
Period 01-04-2020 until 31-12-2022

Rien.dam@outlook.com
HP 081357850260; WA +31 610475590

Reference: M.A.C. Dam, 2022; Land Subsidence in the Coastal Zone of Central Java, Work shop Report. Please provide proper reference to the original authors when you use material from this report.

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	Document / Presentation title	Author (s)
1	Towards solution-oriented technical cooperation on land subsidence (North coast, Central Java)	Mr. Bastien van Veen, Deltares, the Netherlands
2	Detailed analysis of INSAR data set for Central Java	Mr. Thaem Mous, Wageningen University, the Netherlands
3	Figuring the problems on risk disaster management of land subsidence, sea level rise and coastal inundation at northern coast of Java	Dr. Heri Andreas, ITB, Indonesia
4	Land Subsidence in the Coastal Zone of Central Java	Dr. Ahmad Taufiq, Balai Air Tanah (BAT), PUPR, Bandung, Indonesia
5	Quantifying disaster risk due to land subsidence in northern Java	Dr Yus Budiono, BRIN, Indonesia
6	National Task Force Land Subsidence cooperation and collaboration initiatives and proposed projects	Mr. Gusti Prabawa, Co-Chair-Convener Kemenko MarVes, Pokja Amblas Tanah, Indonesia
7	Coastal Land Subsidence and mitigation measures	Prof. Dr. Philip Minderhoud, Wageningen University / Utrecht University / University of Padua, Italy
8	Governance of Land Subsidence: proposing an Adaptive Monitoring Framework	Mr. Nishchal Sardjoe & Rizka Akmalia, Deltares, the Netherlands
9	Local, community level impact of land subsidence and adaptation	Ms. Marie Belland, University of Amsterdam, the Netherlands
10	Land Subsidence and Groundwater Management	Prof. Dr. Gualbert Oude Essink, Deltares, the Netherlands
