



Newsletter of the Unesco Land Subsidence International Initiative

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Water For Food Programme

Water and agriculture are inextricably linked. It is no secret that water is a critical input for agricultural production and as such, is essential to food security. At the same time, agriculture is by far the largest user of water, accounting for nearly 70% of total available freshwater withdrawals, and is a major source of water pollution.

Global population growth coupled with the impact of climate change, is placing severe pressure on already dwindling water resources, and is leading to more frequent incidents of drought, flooding, salinity intrusion and *land subsidence*. In addition, a significant portion of agricultural water is being re-allocated to higher value uses (industrial, urban). Innovative water technologies and practices are key to improving the efficiency and productivity of water in agriculture, resulting in more sustainable food systems, and improved food security.

The Netherlands is a global leader in both agriculture and water management. Yet, despite significant efforts, there are still too few concrete success stories that demonstrate the business case in an integrated approach to water for food. The Water for Food Programme addresses this issue by stimulating and facilitating the Dutch water sector and agrifood partners to develop business cases within this nexus.

Short and long-term objectives

The Water for Food Programme is intended as a multi-year programme, initially starting with a period of two years (2021-2022). The programme's objectives are to bring about:

improved food security, sustainable water use and protection of ecosystems and biodiversity; and, the hands-on acceleration of business cases for the Dutch water sector.

In line with the five key phases outlined below (see timeline), in the short term, the programme seeks to catalyse the development of water-related business cases in the agrifood sector through cooperation and joining forces amongst others with financial institutions. This will illustrate that business models can be achieved through adopting an integrated nexus approach.

The longer-term objective is to establish a sustainable Water and Food hub that connects players in the water and agrifood sector to co-create international projects and to serve as a central

information point. This hub aims to be a platform that continues beyond the life of the programme and that is open to Dutch parties interested in water and agrifood. The Water and Food hub is a platform where business opportunities can be explored and successful pilots be brought to the next stage of scaling up, replication or adaptation to other regions.

This cross-sectoral approach and the focus on financially viable local business cases in the most promising markets are crucial elements in the programme. However, these make the programme more complex. Developing sustainable solutions will take significant effort and multiple interventions, and can only be achieved if all the relevant know-how is shared amongst and put into action by stakeholders. The programme will facilitate this process. By showcasing concrete and viable solutions in the water-agrifood nexus, the programme also aims to further boost the visibility of the Netherlands as the global market leader in the water, agrifood and ecosystems sectors. This will optimise the Netherlands' position in generating future business opportunities and, subsequently, contribute to the Netherlands International Water Ambition (NIWA) and the SDGs.

Ultimately, the programme can serve as a model for large-scale implementation.

Read more: <https://www.netherlandswaterpartnership.com/programmes/water-food-programme>

New Literature

General

Mimura, N. Rising seas and subsiding cities. *Nat. Clim. Chang.* (2021).

<https://doi.org/10.1038/s41558-021-01009-6>

Nicholls, R.J., Lincke, D., Hinkel, J. et al. A global analysis of subsidence, relative sea-level change and coastal flood exposure. *Nat. Clim. Chang.* (2021). <https://doi.org/10.1038/s41558-021-00993-z>

Asia, Megacities

Cao, A., Esteban, M., Valenzuela, V. P. B., Onuki, M., Takagi, H., Thao, N. D., & Tsuchiya, N. (2021). Future of Asian Deltaic Megacities under sea level rise and land subsidence: current adaptation pathways for Tokyo, Jakarta, Manila, and Ho Chi Minh City. *Current Opinion in Environmental Sustainability*, 50, 87-97.

https://www.researchgate.net/publication/350250675_Future_of_Asian_Deltaic_Megacities_under_sea_level_rise_and_land_subsidence_current_adaptation_pathways_for_Tokyo_Jakarta_Manila_and_Ho_Chi_Minh_City

Belgium, Antwerp

Declercq, P.-Y.; Gérard, P.; Pirard, E.; Walstra, J.; Devleeschouwer, X.

Long-Term Subsidence Monitoring of the Alluvial Plain of the Scheldt River in Antwerp (Belgium) Using Radar Interferometry. *Remote Sens.* 2021, 13,

https://doi.org/10.3390/rs_13061160

<https://www.mdpi.com/2072-4292/13/6/1160/pdf>

India, Mohali-Chandigarh area

Kadiyan, N., Chatterjee, R. S., Pranjali, P., Agrawal, P., Jain, S. K., Angurala, M. L., ... & Ray, P. C. (2021). Assessment of groundwater depletion–induced land subsidence and characterisation of damaging cracks on houses: a case study in Mohali-Chandigarh area, India. *Bulletin of Engineering Geology and the Environment*, 80(4), 3217-3231.

<https://doi.org/10.1007/s10064-021-02111-x>

Indonesia, Jakarta

Thanti Octavianti et al.,

Disaster capitalism? Examining the politicisation of land subsidence crisis in pushing Jakarta's Seawall Megaproject

ABSTRACT: This paper offers an analysis of 'disaster capitalism', in which fear of disaster is exploited to facilitate the entry of a capitalist project, with regard to Jakarta's flood policy. After a major flood hit the city in 2013, the Indonesian government launched a flagship megaproject, the National Capital Integrated Coastal Development (NCICD), as the solution for the city's sinking problem. The plan involves closing Jakarta Bay by means of a 32-kilometre (km) offshore sea wall and reclaiming 5100 hectares (ha) of land. Following a corruption scandal in a related reclamation project (for 17 artificial islands), the NCICD plan was evaluated for six months in 2016. Although many criticisms of the plan surfaced during the evaluation period, they were not able to bring about radical change, i.e. cancellation of the project. Informed by the concept of 'critical juncture' (an analytical approach focusing on a short period of time in which actors' decisions have a higher probability of affecting the particular outcome), we analyse the extent to which the framing of the sinking crisis by political actors can explain such a 'near-miss' critical juncture, where change is both possible and plausible but not achieved. Drawing data from newspaper discourse, interviews, and policy documents, we find that the project's proponents have eloquently framed the sinking crisis in order to ensure preference for the seawall policy, including the project concerning the 17 islands that was claimed by the critics as the capitalist part of the project. It can be concluded that the 'disaster capitalism' notion played a significant role in this 'near-miss' outcome..

<https://www.water-alternatives.org/index.php/alldoc/articles/vol11/v11issue2/443-a11-2-10>

Iran, Shahryar County

Ranjgar, B. et al., Land Subsidence Susceptibility Mapping Using Persistent Scatterer SAR Interferometry Technique and Optimized Hybrid Machine Learning Algorithms. *Remote Sens.* 2021, 13, 1326. <https://doi.org/10.3390/rs13071326>

Italy

Cigna, F., & Tapete, D. (2021). Sentinel-1 BigData Processing with P-SBAS InSAR in the Geohazards Exploitation Platform: An Experiment on Coastal Land Subsidence and Landslides in Italy. *Remote Sensing*, 13(5), 885.

<https://www.mdpi.com/2072-4292/13/5/885/pdf>

Japan

Makoto Nishigaki et al.,

Current Status and Future of Groundwater Management in Japan

https://link.springer.com/chapter/10.1007/978-3-030-59320-9_15

Lebanon, Beqaa Plain

Elias C. Massoud et al., Groundwater Depletion Signals in the Beqaa Plain.

<https://www.mdpi.com/2072-4292/13/5/915/pdf>

PR China, Beijing Plain

Li, H., Zhu, L., Guo, G., Zhang, Y., Dai, Z., Li, X., Chang, L., and Teatini, P.: Land subsidence due to groundwater pumping: hazard probability assessment through the combination of Bayesian model and fuzzy set theory, *Nat. Hazards Earth Syst. Sci.*, 21, 823–835, <https://doi.org/10.5194/nhess-21-823-2021>, 2021.

<https://nhess.copernicus.org/articles/21/823/2021/>

PR China, Qinghai Province

Jiawen Bao, Xiaojun Luo, Guoxiang Liu, Ling Chang, Xiaowen Wang, Yueling Shi, Shuaiying Wu,

An improved distributed scatterers extraction algorithm for monitoring tattered ground surface subsidence with DSInSAR: A case study of loess landform in Tongren county, *International Journal of Applied Earth Observation and Geoinformation*, Volume 99, 2021, 102322, ISSN 0303-2434,

<https://doi.org/10.1016/j.jag.2021.102322>.

(<https://www.sciencedirect.com/science/article/pii/S0303243421000295>)

Abstract: In order to effectively detect the detailed subsidence of tattered ground surface composed of many small fragments with the distributed scatterer interferometric synthetic aperture radar (DSInSAR) technique, a fast and accurate distributed scatterer extraction (FADSE), as an improved distributed scatterers extraction algorithm, is proposed and demonstrated in this paper. The emphasis of FADSE is on the improvement of accuracy of extracted DSs and detection efficiency as well. For the purpose, nonparametric estimation and parametric estimation methods are combined into FADSE to fast identify as many accurate statistically homogeneous pixels (SHP) as possible. Then the thresholds of homogeneous pixel number and coherence coefficient are adjusted to select DSs from SHPs. The validation of FADSE was performed in the case of loess subsidence detection in Tongren county, Qinghai Province of China, using 20 Sentinel-1A SAR images acquired between February 2016 and June 2017. Moreover, FADSE was compared with the Kolmogorov-Smirnov algorithm and Fast Statistically Homogeneous Pixel Selection method. Results show that FADSE is capable of efficiently extracting more DSs that are accurate and the detailed subsidence of tattered ground surface can be accurately detected.

PR China, Wuhan

Shi, X., Zhang, S., Jiang, M., Pei, Y., Qu, T., Xu, J., and Yang, C.: Spatial and temporal subsidence characteristics in Wuhan city (China) during 2015–2019 inferred from Sentinel-1 SAR Interferometry, *Nat. Hazards Earth Syst. Sci. Discuss.* [preprint], <https://doi.org/10.5194/nhess-2021-35>, in review, 2021. <https://nhess.copernicus.org/preprints/nhess-2021-35/>

PR China, Yangtze

Qiong Liu et al.,

Estimation of regional groundwater resources carrying capacity in Yangtze River Economic Belt

https://www.e3s-conferences.org/articles/e3sconf/pdf/2021/21/e3sconf_aeecs2021_02007.pdf

Saudi Arabia, Riyadh

Aljammaz, A.; Sultan, M.; Izadi, M.; Abotalib, A.Z.; Elhebiry, M.S.; Emil, M.K.; Abdelmohsen, K.; Saleh, M.; Becker, R. Land Subsidence Induced by Rapid Urbanization in Arid Environments: A Remote Sensing-Based Investigation. *Remote Sens.* 2021, 13, 1109. <https://doi.org/10.3390/rs13061109>

<https://www.mdpi.com/2072-4292/13/6/1109>

Spain, Alto Guadalentín

Fernández-Merodo, J. A., Ezquerro, P., Manzanal, D., Béjar-Pizarro, M., Mateos, R. M., Guardiola-Albert, C., ... & Herrera, G. (2021). Modeling historical subsidence due to groundwater withdrawal in the Alto Guadalentín aquifer-system (Spain). *Engineering Geology*, 283, 105998.

<https://doi.org/10.1016/j.enggeo.2021.105998>

Taiwan, Choshi River alluvial fan

With Tom Burbey as one of the co-authors:

Hone-Jay Chu et al.,

Development of spatially varying groundwater-drawdown functions for land subsidence estimation,

Journal of Hydrology: Regional Studies,

Volume 35, 2021, 100808, ISSN 2214-5818, <https://doi.org/10.1016/j.ejrh.2021.100808>.

(<https://www.sciencedirect.com/science/article/pii/S2214581821000379>)

Study focus

Land subsidence caused by groundwater overexploitation is a critical global problem. The spatial distribution of land subsidence is crucial for effective environmental management and land planning in subsidence prone areas. Because of the nonlinear relationship between subsidence and drawdown due to groundwater exploitation in heterogeneous aquifers, a spatial regression (SR) model is developed to effectively estimate nonlinear and spatially varying land subsidence. Considering various data inputs in the Choshui River alluvial fan, the SR model offers a robust method for accurately estimating the spatial patterns of subsidence using only drawdown as input data.

New hydrological insights for the region

Without requiring extensive calibration or an elaborate numerical groundwater flow and subsidence model, the model provides annual subsidence patterns using a spatially varying relationship between drawdown and resulting land subsidence. Results show that the largest water-level cone of depression occurs in the distal fan area. Nonetheless, the calculated subsidence bowl closely approximates the observed one located much farther inland. The root-mean-square-errors (RMSEs) of annual subsidence is less or equal to 0.76 cm for the SR. Results indicate that the SR model reasonably estimates the spatial distribution of the skeletal storage coefficient in the aquifer system.

The large coefficient that represents high potential of inelastic compaction occurs in the southern inland area, whereas the small coefficient that represents elastic compaction occurs in the northern area and proximal fan. Furthermore, this method can be used efficiently for subsidence management/ regulation and might be widely used for subsidence estimation solely based on drawdown.

Taiwan, Chunghua; Yunlin

Tom Burbey also collaborated in following:

Hone-Jay Chu, Muhammad Zeeshan Ali, Thomas J. Burbey, Spatio-temporal data fusion for fine-resolution subsidence estimation, in: Environmental Modelling & Software, Volume 137, 2021, 104975, ISSN 1364-8152, <https://doi.org/10.1016/j.envsoft.2021.104975>.

<https://www.sciencedirect.com/science/article/pii/S1364815221000189>

Abstract: Land subsidence provides important information about the spatial and temporal changes occurring in the subsurface (e.g. groundwater levels, geology, etc.). However, sufficient subsidence data are difficult to obtain using only one sensor or survey, often resulting in a tradeoff between spatial resolution and temporal coverage. This study aims to estimate the high spatio-temporal resolution land subsidence by using a kernel-based vector data fusion approach between annual leveling and monthly subsidence monitoring well data, while invoking an invariant relation of subsidence information. Subsidence patterns and processes can be identified when spatio-temporal fusion of sensor data are implemented. In this subsidence investigation in Yunlin and Chunghua counties, Taiwan, the root mean square error (RMSE) is 0.52 cm in the fusion stage, and the mapping RMSE is 0.53 cm in the interpolation. The fused subsidence data readily show that the subsidence hotspot varies with time and space. The subsidence hotspots are in the western region during the winter (related to aquaculture activities) but move to the inland areas of Yunlin County during the following spring (related to agricultural activities). The proposed approach can help explain the spatio-temporal variability of the subsidence pattern.

Turkey, Konya

Orhan, O. Monitoring of land subsidence due to excessive groundwater extraction using small baseline subset technique in Konya, Turkey. Environ Monit Assess 193, 174 (2021).

<https://doi.org/10.1007/s10661-021-08962-x>

USA, Mississippi-Delta

Mississippi River Delta: Land Subsidence and Coastal Erosion

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Department of Natural Resources, College of Agricultural, Consumer, and Environmental Sciences, University of Illinois, Urbana, Illinois, USA.

DOI: 10.4236/ojss.2021.113008

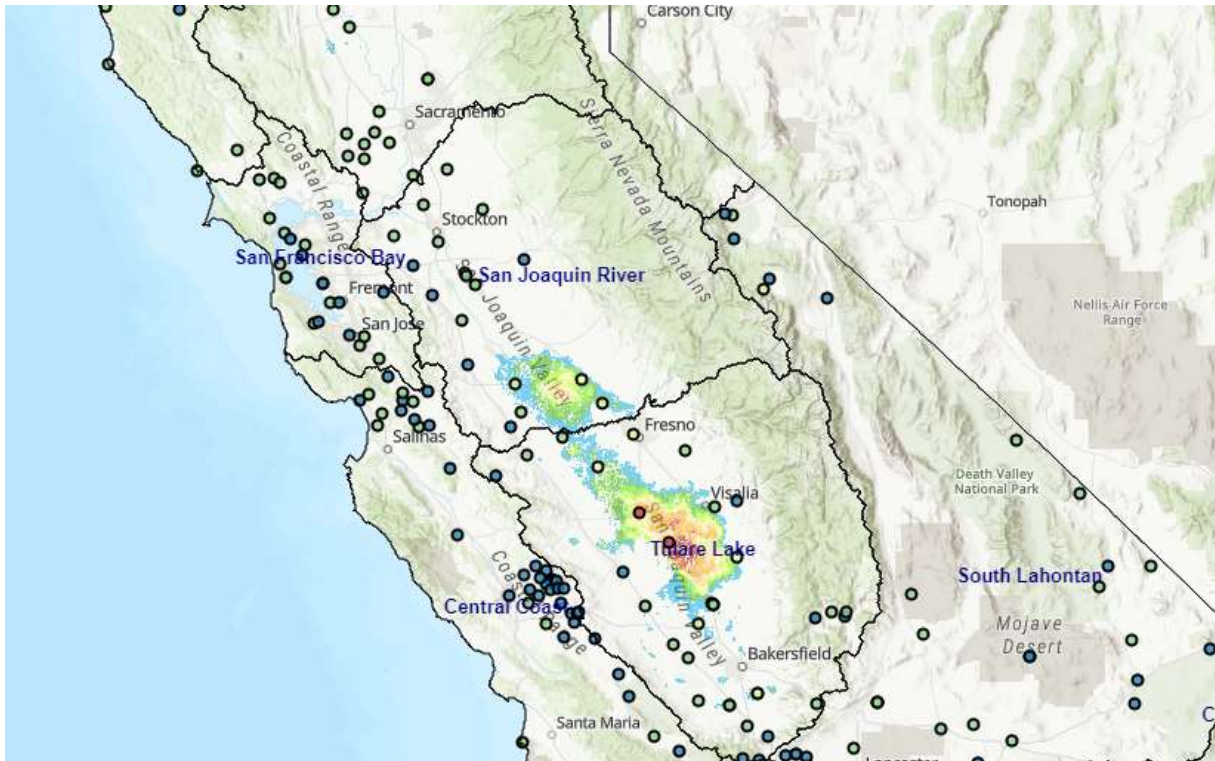
<https://www.scirp.org/journal/paperinformation.aspx?paperid=107757>

Subsidence Maps

The California Groundwater Update 2020 is ready:

<https://storymaps.arcgis.com/stories/2a301109fd984ab98b0217c7c6a6e754>

It contains – besides a lot of information about groundwater – interactive subsidence maps:



From the Press

Climate News Network:

World's coastal cities face risk from land and sea

Now a new study in the journal Nature Climate Change has found that 58% of the world's coastal citizens live on soil and bedrock that is collapsing beneath their feet. Fewer than 1% are settled on terrain that is uplifting. Most are exposed to possible relative sea level rises of between 7.8mm and 9.9mm a year.

<https://climatenewsnetwork.net/worlds-coastal-cities-face-risk-from-land-and-sea/>

National Geographic



Sinking land and rising seas: the dual crises facing coastal communities.

<https://www.nationalgeographic.com/environment/article/sinking-land-rising-seas-dual-crises-facing-coastal-communities>

12 Rapidly Sinking Cities

Michelle provided us with following:

Major cities around the world are in danger of disappearing.

By Maria Marabito

Updated March 28, 2021

As attention mounts on this pressing problem facing major cities around the world, so are efforts to prevent and reverse the damage occurring. The UNESCO Land Subsidence International Initiative tackles the issue of disseminating credible and applicable information regarding land subsidence as it applies to sustainable development and prevention. The initiative raises awareness, publishes guidelines, and fosters improved planning.

<https://www.treehugger.com/sinking-cities-5118499>

India, Andra Pradesh

A Central committee has asked the Environment Ministry to take into consideration likely threat of land subsidence in Krishna-Godavari Basin in Andhra Pradesh while giving clearance to any underground oil or gas exploration project in future.

<https://www.hindustantimes.com/delhi/central-panel-wants-study-on-kg-basin-land-subsidence-threat/story-4l0Xif45f2fozNLZAICykl.html>

Indonesia, Pekalongan

This city in Java could disappear in 15 years, due to land subsidence and coastal flooding:

<https://www.channelnewsasia.com/news/climatechange/indonesia-pekalongan-land-sinking-coastal-flooding-disappear-14279658>

Iran, Groundwater recharge zones

Jaafarzadeh, M.S., Tahmasebipour, N., Haghizadeh, A. et al. Groundwater recharge potential zonation using an ensemble of machine learning and bivariate statistical models. Sci Rep 11, 5587 (2021). <https://doi.org/10.1038/s41598-021-85205-6>

Saudi Arabia, Tabah

Tabah and its environs were an area of volcanic activity. In 1983, land subsidence, accompanied by fissures and cracks, led to the development of fractures that ran for long distances along the crater leading to the evacuation of its inhabitants.

The situation worsened in the 1980s, when a development project began in the area and an asphalt company began paving roads, a process for which the village's underground water had to be extracted.

The changes to the water table led to a series of loud sounds and land subsidence that destroyed several homes. It was then that the government decided to move the villagers to safety and compensate them by providing them with homes outside the volcanic zone.

<https://www.arabnews.com/node/1764096/saudi-arabia>

Taiwan, High Speed Rail

The Taiwan High Speed Rail Corporation has released a report on land subsidence along its tracks.

The report focused on four areas where land subsidence has been occurring, one in Changhua and three in Yunlin.

The report finds that the rate of subsidence has decreased in Changhua, but has picked up in the Yunlin areas.

However, the report says the affected tracks are all still safe to use.

Taiwan, Water project

Taiwan tackles land subsidence with water project.



<https://taiwantoday.tw/news.php?unit=6,23,45,6,6&post=10392>

United States, California

Next Steps Considered for Santa Venetia Project:

<https://www.marincounty.org/main/county-press-releases/press-releases/2021/dpw-santavenetiaflood-031621>

Vietnam, Mekong Delta

Netherlands ready to support VN in improving the Mekong Delta's resilience to climate change.

<http://news.chinhphu.vn/Home/Netherlands-ready-to-support-VN-in-improving-the-Mekong-Deltas-resilience-to-climate-change/20213/43194.vgp>

Land subsidence endangers Mekong Delta:

<https://vnexplorer.net/land-subsidence-endangers-mekong-delta-a2021138780.html>