Salt intrusion and salinization management in coastal areas for a sustainable food production

Supervisors: Dr Nicoletta Leonardi (university of Liverpool);

External supervisors and institution: Dr. Nima Shokri (University of Manchester)

Primary Contact Name and Email: N.Leonardi@liverpool.ac.uk

Project Summary

Coastal areas accommodate great part of the world population, and are the food baskets for many nations because they support much of the world's fisheries, and agriculture. Coastal areas are also among the most ecologically diverse ecosystems on earth (e.g. Leonardi et al., 2013; Leonardi and Fagherazzi, 2014; Leonardi et al., 2016).

With almost two thirds of the world population experiencing a critical food deficit and more than a third of the world soil suffering from degradation, sustainable food production is a big challenge.

Salt intrusion and soil salinization have been causing land degradation in many coastal areas worldwide (e.g. Yangze River, China; Mekong River Delta, Vietnam and Nile Delta, Egypt), and have been compromising food production, and freshwater availability. This land degradation is exacerbated by groundwater extraction, urbanization, sea level rise, and increase in both frequency and magnitude of storm surges (Osman et al., 2017; Shokri-Kuehni et al., 2017).

This project aims at investigating issues related to salt intrusion, and soil salinization in coastal areas by combining numerical models and experimental data. The students will look into how the effects of transport properties of porous media and external conditions influence the dynamics of seawater intrusion in soil.

The project follows interdisciplinary criteria as it aims at coupling the large scale frameworks used by ocean scientists and small scale models utilized by soil physicists and chemical engineers.

Research questions

- How do external agents such as sea level rise, and storm surge occurrence influence the risk of soil salinization, and salt intrusion in coastal areas?
- How soil properties, water content, and heterogeneity influence the extent of soil salinization and saltwater intrusion?
- How different land uses alter the risk of land degradation?
- Are there possible mitigation strategies to be adopted to reduce the risk of salt intrusion, and

salinization in coastal areas?

Methods

A combination of numerical models and experimental data will be used. The experimental station in Manchester will enable the student to explore the impact of parameters such as liquid composition, soil properties, heterogeneity and water content on the extent of soil salinization at the scale of porous media. The hydrodynamic, sediment transport, and morphological model Delft3D has been widely tested and has been developed to study costal and riverine environments. The numerical model will be used to explore the problem at a catchment scale, and for idealized test cases. Part of the project will aim at combining the information obtained from small scale experiments into the large scale numerical models. Model performance, and predictions will be tested by means of Landsat images, and specifically by looking at band colors for the identification of areas subject to salt intrusion. The project will first start by looking at idealized test cases, and then to real case scenarios such as The Mekong Delta, and the Yangze River. The numerical model setup for test cases on interest is already available.

Work plan

- Formulation of key questions based on literature review, and available data.
- Familiarization with the numerical models, and experimental station.
- Execution of laboratory and numerical experiments aimed at exploring the specified research questions.
- Evaluation of models performance and predictions
- Data analysis, and results interpretation: Results will be critically analysed and discussed to provide useful indicators and parametrizations aimed at identifying the role of climate change and different external forcing on soil salinization and salt intrusion.
- Results dissemination: research outcomes will be disseminated through presentations at international conferences, workshops, as well as the publications of scientific papers and a final report.

Ghost forest caused by salt intrusion and sea level rise, http://news.trust.org/

References

Fagherazzi, S., Edmonds, D.A., Nardin, W., Leonardi, N., Canestrelli, A., Falcini, F., Jerolmack, D.J., Mariotti, G., Rowland, J.C. and Slingerland, R.L., 2015. Dynamics of river mouth deposits. *Reviews of Geophysics*, *53*(3), pp.642-672.

Leonardi, N., Canestrelli, A., Sun, T. and Fagherazzi, S., 2013. Effect of tides on mouth bar morphology and hydrodynamics. *Journal of Geophysical Research: Oceans*, *118*(9), pp.4169-4183.

Leonardi, N. and Fagherazzi, S., 2014. How waves shape salt marshes. Geology, 42(10), pp.887-890.

Leonardi, N., Ganju, N.K. and Fagherazzi, S., 2016. A linear relationship between wave power and erosion determines salt-marsh resilience to violent storms and hurricanes. *Proceedings of the National Academy of Sciences*, *113*(1), pp.64-68.

Osman, A., Goehring, L., Patti, A., Stitt, E.H. and Shokri, N., 2017. Fundamental investigation of the drying of solid suspensions. Industrial & Engineering Chemistry Research.

Shokri-Kuehni, S.M., Rad, M.N., Webb, C. and Shokri, N., 2017. Impact of type of salt and ambient conditions on saline water evaporation from porous media. Advances in Water Resources, 105, pp.154-161.